Research and Preparation of Video Demonstrations and Evaluation of Their Effectiveness

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Research and Preparation of Video Demonstrations and Evaluation of their Effectiveness

Appendices

Introduction

This paper is the culmination of a six month project begun in May 1996. The project involved researching, testing, and evaluating chemical demonstrations for a series of video tapes for a General Chemistry course. It was to be offered only a short 3 months from the original undertaking of the project.

Background

In Fall 1996, the University of Colorado at Denver offered for the first time an extended studies distance learning course for General Chemistry. The students who enrolled received seven video tapes which contained lecture material, demonstrations and visual aids. In addition, students received a course outline and printed lecture notes. The students were required to use a general chemistry text to accompany the course, but the course was designed so any general chemistry text would suffice. The students visited campus seven times during the semester for a long day of labs and testing. On-line help sessions were regularly scheduled with the instructor so the students could receive help working problems and understanding concepts.

The advantages of a course like this are many. 1) It allows individuals to work at their own pace reviewing material when necessary and moving quickly through material with which they are comfortable. 2) With the many requirements of work and personal lives, students can work around complex family and employment schedules. 3) For parents who stay at home with their children, no sitter is required while the parent "goes to class". 4) Since many students live and/or work a great distance from campus, the travel time is significantly reduced by only having to come to campus seven times for this course. The disadvantages are the lack of external motivation from the regular presence of an instructor and the sometimes slower feedback loop.

Purpose

In order to complete the video tapes for the extended studies General Chemistry course, demonstrations for use in these video tapes needed to be selected, tested, and presented. In May 1996, a list of the seven topics which would be covered in this course was developed. The topics were stoichiometry, gases, thermodynamics, kinetics, equilibrium, atomic structure and periodicity, and bonding. Henceforth, topics will be referred to as chapters or videos interchangeably. The demonstrations selected had to be applicable to the subject material being discussed, or when the material being discussed did not lend itself well to any demonstration or visual aid, we took a "commercial break" and threw in a gratuitous demonstration to break the monotony. The selection criteria for demonstrations and visual aids used will be discussed later, in the sections covering analysis of demonstration literature and demonstration testing and incorporation sections. To clarify the difference between a visual aid and a demonstration, a visual aid is defined as a visual analogy. One illustrates a scientific concept by showing a related event or activity. For example, a visual illustration of a rate limiting step used sand being poured through four funnels in series. One of the four funnels contained a restricted opening, while the other funnels had a relatively large exit diameter. The funnel with the constricted opening served as the rate limiting step for the overall reaction. A demonstration uses the actual chemical reaction to illustrate the principle being discussed. Reacting ammonium chloride with barium hydroxide demonstrated an endothermic reaction which absorbed heat from the surroundings and resulted in a noticeable drop in temperature.

Rationale

Research suggests that demonstrations and visual aids help a student understand a concept better and begin to think critically about the concept (Joyce, 1992). Demonstrations can be a powerful means of sparking student interest, focusing attention, and initiating learning. For advanced students who already have an understanding of the concepts, the demonstrations can serve to keep the lecture material from becoming boring. Seeing a principle in action can cause the advanced students to seek answers to further

questions the demonstrations have raised for them. Many instructors like to think demonstrations can ignite a fascination with chemistry and stimulate thought processes which develop a desire for further knowledge. As indicated by Brennan (1996), a report by the National Science Foundation states " too many undergraduate students leave [science] courses because they find them dull and uninteresting."

There are differing opinions on the value of demonstrations in the classroom versus actual laboratory experiments. Numerous reactions can have dangerous outcomes if not conducted properly; thus demonstrations are typically presented by an experienced chemist who is aware of the hazards (ex. fire, explosion). Thus using demonstrations, many more reactions can be observed by less experienced students. There are also additional benefits of demonstrations.

> Arguments in favor of demonstrations have included (among others) safety, cost, time, and efficiency. Counter arguments favor the laboratory as the only setting for discovery learning. Yet, the main conclusion drawn from over 50 studies is that there is no clearly superior method (laboratory or demonstration) for illustrating and learning principles. The recommended method is that lecture demonstrations complement the more direct hands-on laboratory experiences. A properly delivered demonstration can be more discovery-oriented and meaningful than a "cook-book" verification laboratory activity. An optimal learning environment maximizes meaningful learning by utilizing a mix of different degrees of both reception and discovery learning (O'Brien, 1991).

Demonstrations should not be too numerous or too sophisticated to overshadow the importance of their educational benefit, nor should they be presented without associated concepts.

> "Demonstrations are generally used with the intention of helping to promote student comprehension and stimulate student enthusiasm. However, throughout this century, the pendulum of opinion on the value of using demonstrations in the chemistry classroom has never stopped swinging. Some teachers have made this the focal point of their courses whereas others have been highly critical of this mode of instruction (Beall, 1996)."

In accordance with Joyce (1992), demonstrations are the concrete visualizations which help cement the new information being presented with concepts which may have already been known.

According to Wesley Smith (Shakhashiri, 1983), there are six characteristics of effective demonstrations which best promote student understanding. Demonstrations must be: 1) timely and appropriate; 2) well prepared and rehearsed; 3) visible and large scale; 4) simple and uncluttered; 5) direct and lively; and 6) dramatic and striking. These criteria were the basis for the specific demonstrations included in the video tapes. In addition, we attempted to have the physical display of the demonstrations be such that they were uncluttered and striking.

In planning a lecture demonstration, one must always make clear the reasons for presenting it, and convey that to the students (Shakhashiri). This will help the student to associate the demonstration with the proper theories and equations. When the demonstration does not illustrate the lecture material currently being discussed, students should clearly be informed. This situation might arise when there is not a suitable demonstration of the principle, but the instructor hopes to regain students' attention. When at all possible, demonstrations should be used to achieve specific teaching goals, even when that goal is sometimes just to maintain intellectual excitement or awareness. Demonstrations can also be used to nurture students' observational capabilities. By the teacher asking questions and then answering them as a class, a student can affirm his/her abilities without the apprehension of confrontational questioning. This method can be used to strengthen the students' confidence in their critical thinking capabilities. Students who lack these skills can start to foster them from observing them in action.

A given demonstration may illustrate more then one chemical principle. It is important not to overtax the students' conceptual abilities by trying to teach too much at one time. In Models of Teaching, by Joyce et al. (1992), it is asserted that learning evolves from the information and concepts already possessed by the students. If little or nothing is known, it is best to introduce narrow, concrete, understandable topics first to provide a background for further understanding. There must be a suitable mental anchor before new ideas will be incorporated into the cognitive structure. As the mental

information processing system acquires new ideas, it reorganizes itself to accommodate those ideas and relate them to complimentary concepts. Before presenting a new idea in a demonstration or lecture, it is beneficial to realize some prior knowledge may need to be reviewed and reactivated before proceeding with the new concepts.

There is a framework for the purpose of including lecture demonstrations in teaching chemistry (Shakhashiri). At the first level, students observe chemical phenomena and learn chemical facts as related to the demonstration. The associated lecture material explains these observations in terms of models, laws, and theories at the second level. At the third level, the instructor can introduce mathematical equations and computations. By referencing the demonstration just observed, the teacher can inquire from the students what would have happened if one of the variables or products were altered. Across each of these levels, the teacher's attitude and motivation in presentation can directly influence the reception by the student. This framework is not practical in a video series format, but can be used for taped demonstrations shown to a class. There is a lot of direct, immediate input/interaction with the instructor necessary for understanding principles in more complicated demonstrations, which is not possible in a video.

> Generating and aiding the resolution of cognitive conflict is a primary job of a teacher. Conventional "two by four" teaching too often limits students' experiences to answers found between the two covers of the textbook and the four walls of the classroom and produces "bored" students. Such "teacher instruction without student construction" has been characterized as words transferred from the lecturer's notes to the students' notebooks without passing through the minds of either (O'Brien).

To promote a "minds-on" conceptual learning, students must be shown the materials and processes which are chemical. Instructors hope these will instill enthusiasm and understanding in the students.

The student's mind must be engaged to perceive, filter, and transform sensory data into concepts and models within his/her own particular framework (O'Brien). Science must be related to the students' experiences so they understand the concepts as they apply

to the real world, not just the science classroom. Use of everyday products and equipment is recommended whenever possible to help convey this to the students.

I remember, from my undergraduate college days, seeing a demonstration that cycled between orange and blue. I know now this was the Briggs-Rauscher reaction. The only problem is that I don't ever remember having a chemical principle associated with it. One wonders how many demonstrations fail to have a learning objective associated with them, and how many of those are remembered some time after witnessing them.

Many demonstrations exist which are interesting to watch, yet do not illustrate a concept which is suitable for the General Chemistry course material or even understandable at this level. The thought process behind the demonstration selections was to associate a specific principle with a visual image. This will help students internalize the concept, as well as lay the foundation for future chemical knowledge.

Analysis of Demonstration Literature

With the project task properly defined, research and evaluation of the demonstration literature was necessary. Direct sources for demonstrations included books and journal articles. Indirect sources for demonstrations could be found in textbooks. Demonstrations taken from indirect sources required some trial and error to get reproducible results since procedures were not explicitly given. Resource lists can be found in Appendix A.

The Chemical Educator can be found on the internet (http://journals.springer-ny.com/chedr), and it has some demonstrations listed. However, this is a fairly new resource which is still under development. At the time of this project it was incomplete and thus not very helpful.

With resources identified, demonstrations were reviewed with the following criteria in mind. First, demonstrations needed to be applicable to the principle being discussed. Next, determination was made, from the procedure and expected results, as to which demonstrations would be visually or audibly acceptable and worthwhile pursuing. This meant a color change, volume change, or precipitate needed to be formed or a loud noise needed to accompany the reaction . Some literature did not provide this information

which could only be determined by demonstration testing. The Shakhashiri (Shakhashiri, 1983) books were especially helpful because they included this information as well as a materials list, procedures, hazards, disposal information, and a summary of the background and theory.

Demonstration Testing and Incorporation

Actual testing of the demonstrations proceeded chronologically with the order of the chapter topics. Before testing any demonstrations, selections were reviewed and any considered too dangerous were eliminated. With an approved list of demonstrations, laboratory work began.

Some demonstrations were actually visual aids, with very few or no chemical reactions, to serve only as illustrations of physical principals. This was the case with many of the gases demonstrations. Several of the selected visual aids were eliminated because they did not accurately represent the principle or law (poor analogies). Each demonstration involving chemical reactions was tested. The details of each specific demonstration or visual aid are given in Appendix B.

In many instances, the demonstrations worked correctly the first time as described in the research literature. To ensure the reproducibility of these results, the demonstrations were repeated. On three or four occasions, several successful demonstrations illustrated the same principle. This was the case for three cobalt equilibrium demonstrations. Only the most visually appealing of these was selected for actual incorporation.

When a demonstration did not work correctly, repeated attempts were made to determine what needed to be modified. Concentrations were increased and decreased, and other reactants substituted when alternate procedures were given. In at least one demonstration, the ammonia fountain, only the physical set-up of the apparatus needed to be modified. If any of the demonstrations continued to prove unsuccessful, they were eliminated.

Of the successful demonstrations, evaluations of the acceptability for videotaping were determined reapplying the same criteria as before (color, volume, noise, precipitate),

and an additional stipulation was now included. The demonstration either had to be completed in 1-3 minutes or time-lapse camera work had to be able to be used. If the time limitation could not be met, the demonstration was moved to the unsuccessful list.

If all the criteria were met, a decision was then made as to the most appropriate place to perform the demonstration. Factors here were safety, logistics, lighting, and time. Demonstrations which produced noxious gases were done in the laboratory under a ventilation hood. Some logistic limitations prevented the demonstrations from being performed anywhere but in the laboratory. Any demonstration not performed "live" during the lecture is considered pre-taped. Pre-taped demonstrations had several advantages due to the video medium. Labels could be superimposed by text graphics onto items within the film to clearly identify them. This was used in the flame test to identify each of the salts in the individual watch glasses. In addition, by the use of a technique called chroma key, which superimposes one object over another, similar to that used on televised weather reports, demonstrations could be projected in the background while the lecturer highlighted equipment and changes occurring in the reaction. Other advantages of pre-taping in the laboratory were the ability to use time-lapse camera work and the capability to maintain a close-up focus of specific details such as the temperature change in a thermometer. Pre-taping in the studio allowed the lighting to be adjusted to maximize the impact of the demonstration.

Table 1 provides a summary of the number of demonstrations attempted, successfully completed, and incorporated. On the left column is a list of each chapter topic. Across each row is the number of demonstrations which were attempted, the number successful, and the number actually incorporated into the video tape. The remarks column lists the reasons demonstrations were not incorporated. A specific example is the thermodynamics chapter. Fourteen demonstrations were attempted. Eleven of those were successful. Of the successful, eight were actually incorporated into the video. The thermite reaction was not incorporated due to safety concerns. Two additional demonstrations were not visually appealing due to lack of contrast on the camera and were not incorporated. Located in Appendix C is a list of demonstrations or visual aids

incorporated into each chapter, including some of the demonstrations which were not incorporated.

Table 1. Demonstration Tally

	DEMONSTRATIONS			Remarks -- (i.e. why not incorporated
Chapter	Attempted	Successful	Incorporated	
1. Stoichiometry	9	8	8	DW - 1
2. Gases	7	7	7	
3. Thermodynamics	14	11	8	V - 2, S - 1
4. Kinetics	11	8	7	S - 3
5. Equilibrium	11	9	8	DC - 1, S - 1
6. Atomic Structure	7	7	6	DC - 1
7. Bonding	7	5	5	DW - 2
TOTAL	66	55 (83%)	49 (74%)	

KEY:
DW - Didn't work
S - Safety
DC - Duplicate Concept
V - Not visually acceptable

Development of New Demonstrations or Visual Aids

Most demonstrations could be incorporated as published or with minor modifications. However, in preparing for the kinetics tape, research did not yield an accurate or appropriate demonstration for a rate limiting step. Through ideas gleaned from related demonstrations and analogies found in the literature, we developed a new demonstration. Colored sand is poured through a series of four glass funnels stacked vertically with equal distance separating there exit openings. If they have equal exit diameters, the series of funnels gives a constant flow of sand which has no rate limiting step. If one of these funnels is plugged so that the exit diameter is much smaller, sand is slowed at this step. It becomes the rate limiting step. The reaction is the movement of sand through the funnels, which can now only proceed to completion as fast as this slowest step will allow.

Assesment of Demonstration Effectiveness - Survey

After students had been given time to view the first three videos, a 21-question survey was given to the 22 extended studies general chemistry students enrolled in the distance learning course. The survey was given on the same day as a test covering Videos 2 and 3 was being administered. This was the second test of the semester. The survey included questions on the students' previous chemistry background, demonstrations in Videos 2 and 3 (gases and thermodynamics), and general perceptions of the demonstrations. It also included a section for general remarks covering any aspect of the course. A copy of the survey can be found in Appendix D.

Results and Interpretation

Detailed survey results, in graphical form, can be found in Appendix E, but summarized here are the general observations. As seen in Table 2, of the 22 students surveyed, 19 (86%) had completed high school chemistry. For over half of them, it was 11 years or more ago. 45% of the students had enrolled in a college chemistry course prior to this one, yet only seven (32%) actually completed their chemistry course. The remainder withdrew from their course within seven weeks.

Table 2. Student Background

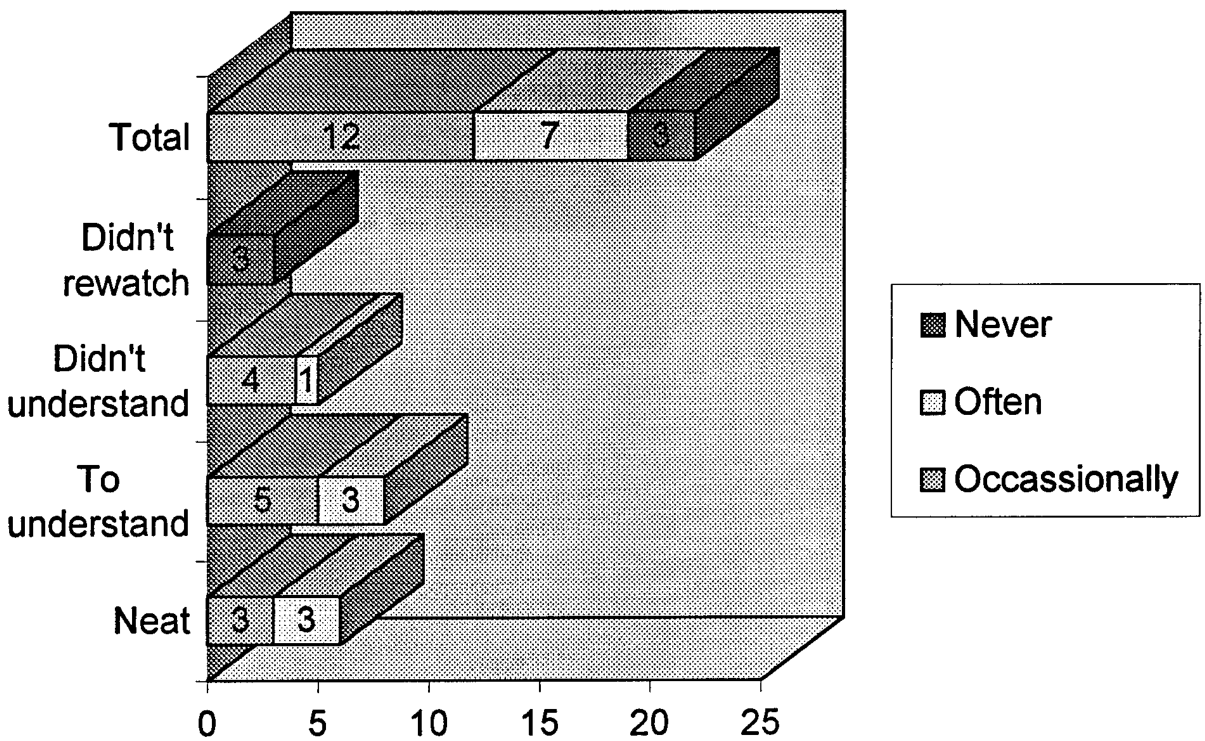
Date Survey Given: October 19, 1996 N = 22	Number of Years Ago				
	1-5	6-10	11-15	16+	N/A
Students completing High School Chemistry 19 (86%)	3	5	4	7	0
Students with previous College Chemistry Course 10 (45%) Completed course 7 (32%)	5	1	0	2	2

It is important to note that on the day of the second test, all of the students had viewed all or part of Videos 2 and 3, yet one student reportedly had not watched Video 1, on which the students had previously been tested. Questions in this survey covered specific demonstrations in these videos which the students had watched. With the exception of three, the students found the presentation of the demonstrations and the film quality excellent or good. Those three students experienced problems with the sound quality and film clarity and rated the film quality poor.

Seven (32%) of the students often watched the demonstrations multiple times, twelve (54.5%) occasionally did, and three (13.5%) never (see Figure 1). Reasons given for watching the demonstrations multiple times varied. Eight (40%) of the students found re-watching the demonstration helped them understand the principle being illustrated. Seven (35%) thought the demonstrations were "neat" and five (25%) re-watched them because they did not understand them the first time.

Most (90%) students found the explanations accompanying the demonstrations to be thorough or adequate. Only two (10%) students found the explanations lacked depth or were inadequate. There were two interestingly dissimilar additional comments made by the students on this question. One student thought there was too much explaining, the other thought there could have been more depth and discussion on the demonstration. With the varied background of the students, one possibly received a more in-depth previous background on the subject or one may have assimilated the information quickly and felt an easy concept was being over discussed. In the opposite view, one student may have been trying to comprehend the principle to a greater extent than was being discussed.

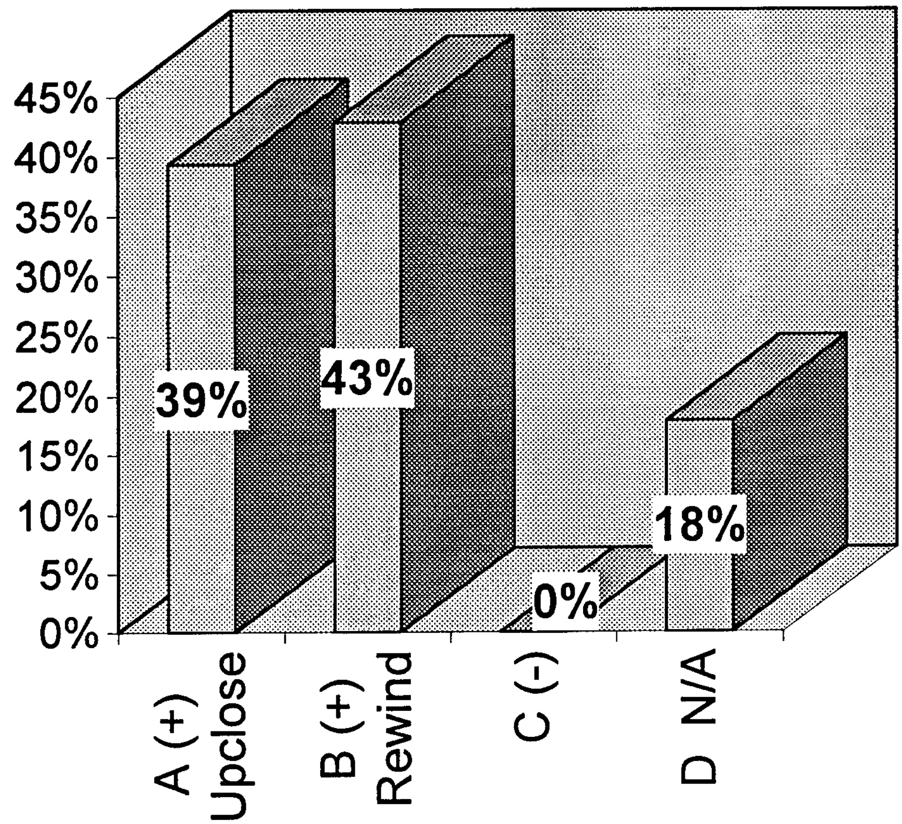
Figure 1. Reasons for re-watching



The majority of the students who had experienced demonstrations in a lecture said the demonstrations in the videos were as or more interesting or valuable than demonstrations observed in a lecture hall (see Figure 2). They may have seen demonstrations in other lectures, in high school chemistry presentations, or similar forums with which they could compare. None of the students who had previously seen demonstrations gave a negative response indicating the demonstrations were distracting or a waste of time. However, five students had never seen lecture demonstrations before and had nothing to compare with these demonstrations. The purpose of this question was to determine why the demonstrations were more interesting or valuable. Of the favorable responses, 39% preferred the video demonstrations over lecture demonstrations because

they could see the demo up-close and 43% preferred them because they could rewind them to watch the demos again.

Figure 2. How interesting or valuable



Overall a majority of the students (82%) thought the demonstrations were a valuable addition to the videos with respect to understanding the concepts. A few (18%) thought the demos were fun and interesting, but not necessary to their understanding. There were no responses indicating the demonstrations were distracting from the lecture material or that they were a waste of time.

The majority of the survey concentrated on the specific demonstrations in Videos 2 and 3. The students had not yet covered Video 4 material, and Videos 5-7 were still in production at the time of the survey. Students were allowed to give more than one response if it was applicable. Figures 3 and 4 provide a cumulative summary of responses.

Figure 3, entitled "Student Response per Demo", contains a summary of each response given for every demonstration. Along the horizontal axis are each of the demonstrations which questions were asked about. The vertical axis gives the number of answers per possible response. The responses possible are given in condensed form in the key, however they correspond to the following.

COLOR	RESPONSE
Lavender	"I don't remember the demonstration."
Maroon	"I don't remember what principle the demonstration illustrated."
Yellow	"I understood the principle before the demonstration illustrated it."
Pink	"I understood the principle better before the demonstration illustrated it because the demonstration confused me."
Green	"I found that the demonstration helped me to understand the principle better."
Peach	"I did not understand the principle until I saw the demonstration."
Blue	"I had seen the demonstration before this video."

There were clearly two distinct trends. The yellow areas indicate the number of students which understood the principle before seeing the demonstration. There were a great number of responses here for every demonstration with the exception of the coupling, the endothermic, and the potassium permanganate/glycerine reactions. Remembering that more than one response could be given for a specific demonstration, notice the even greater number of responses given in the green areas. This indicates an even greater understanding of the principle, even if they understood it before seeing the demonstration. Numerous students indicated they understood the principle before seeing the demonstration, yet it helped increase their understanding, in addition to what they already knew, by seeing the demonstration.

Figure 4, entitled "Opinions about the Demos in Videos 2 & 3", provides a summary of the information in Figure 3 without the trends visible. The total number of answers per response are given. In addition to the large number (66) of responses for understanding before, there was an even larger number (134) of responses for

understanding the principle *better* with the demo. It is encouraging to note that relatively (34) few students failed to remember the demonstration or the principle it illustrated. There were very few demonstrations (7) which had been seen before. There were an equal number of responses (16) that the demonstrations were confusing and that the students only understood the principle upon seeing the demonstration.

An example of duplicate numbers of responses, 4 each, within the same demonstration was the thermodynamic coupling reaction. Students indicated this demonstration was the most confusing, but most often this demonstration also provided understanding of the concept where there was none to begin with. The question and responses provided are rather thought provoking. Did the students really understand the principle with the demonstration, or did they just think they did? There was no way provided on this survey to verify whether or not the students really understood the principle when they stated they did. This line of questioning leads to the conclusion that more in-depth pre- and post-testing needs to be accomplished. Along with this, evaluation of actual student problem solving to measure understanding of the principle needs to be conducted.

Figure 3. Student Response per Demo

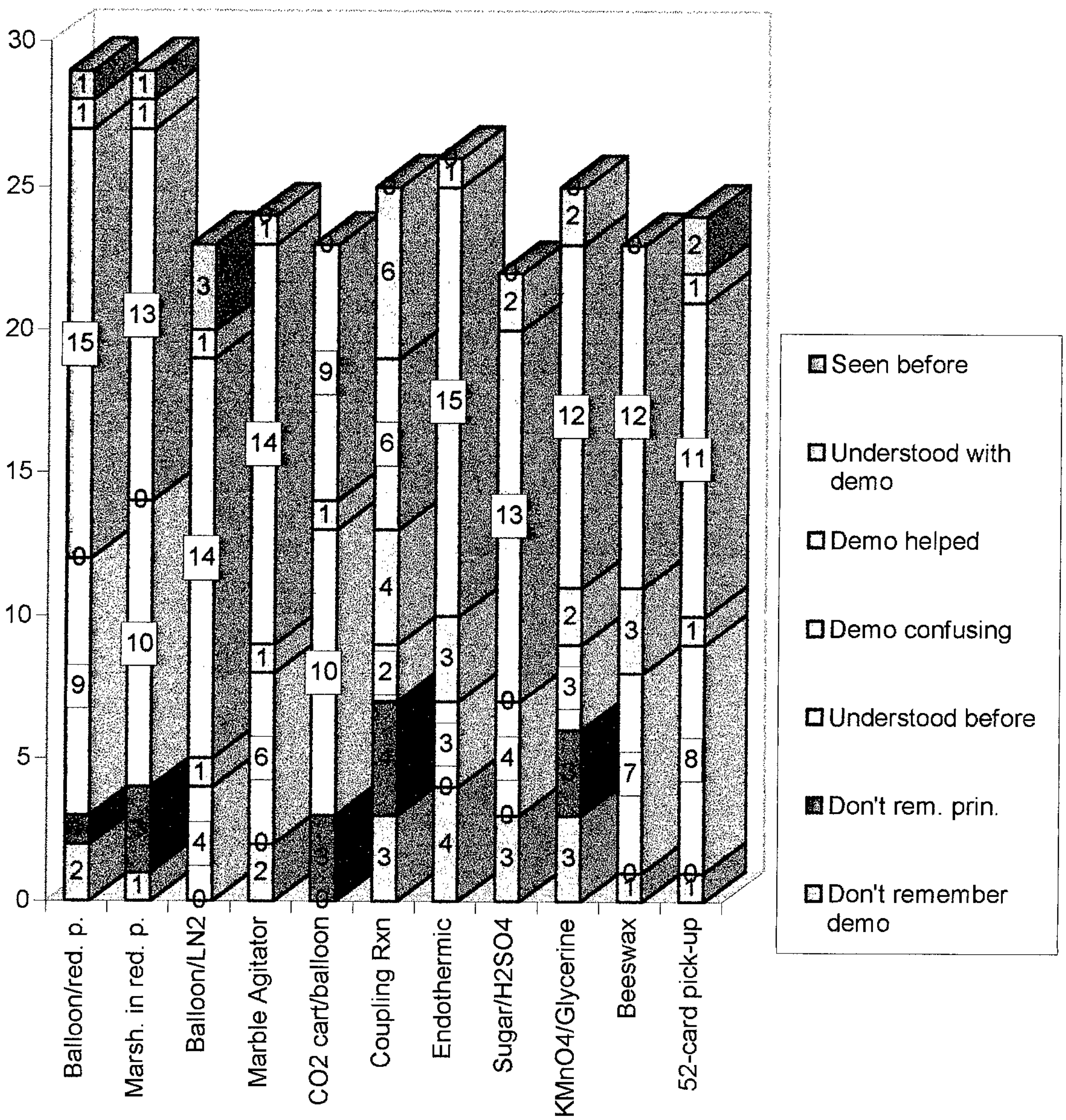
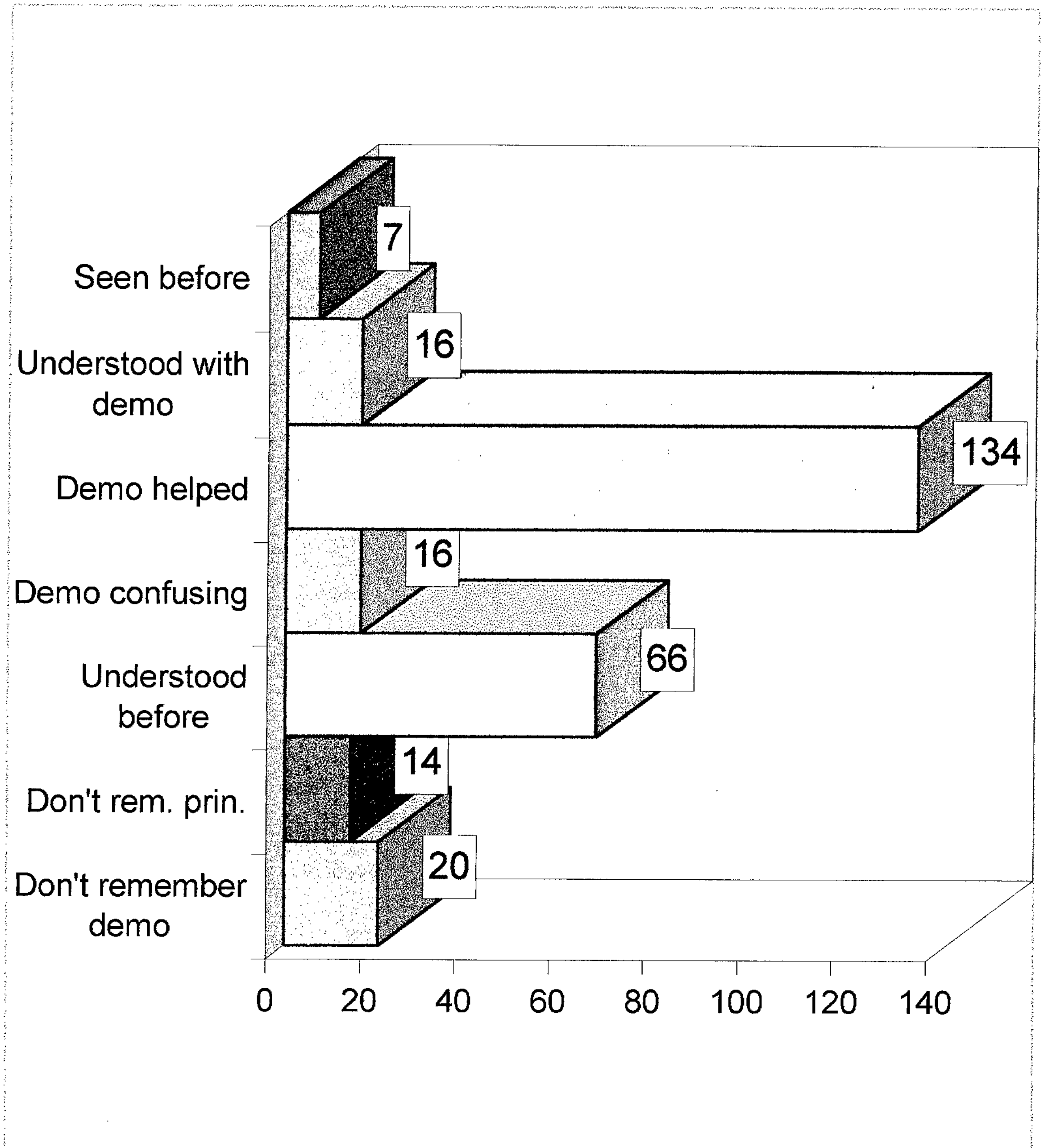
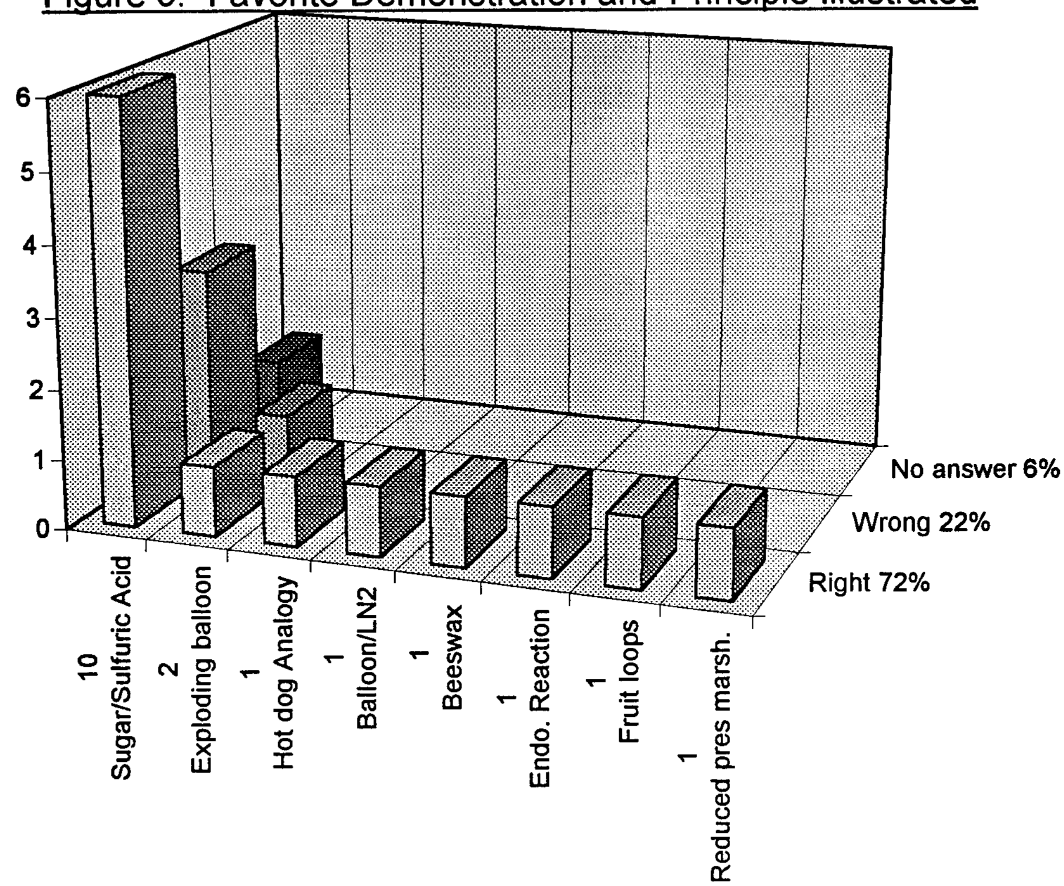


Figure 4. Opinions about the Demos in Videos 2 & 3



The most quantitatively informative question asked was "What was your favorite demonstration in the tapes you have watched and what principle did it illustrate?" Figure 5 illustrates the responses. Eight different demonstrations were listed as the favorite as seen on the horizontal axis. The number of students giving the demonstration as favorite is seen above the demonstration name.

Figure 5. Favorite Demonstration and Principle Illustrated



Ten of the responses said the dehydration of sugar by sulfuric acid was the favorite. For all of the favorite demonstrations listed, the students then gave the principle it illustrated. These are seen on the diagonal axis. Overall, 72% of the students stated the appropriate principles being demonstrated and only 22% gave an incorrect principle. One student did not answer this question. When students provided an incorrect principle but said they

understood the concept, there was a question of how much knowledge they really gained from the demonstration. With more time and surveys, this can be further expanded to accurately determine if actual understanding is gained with the use of demonstrations.

The final section of the survey asked for additional comments on the lecture, demonstrations, or any related aspect of the course on which they wished to comment. These comments are included in Appendix E. Three key comments are selected for inclusion in this paper.

1) 'Most demos are good at reinforcing concepts. I think it helps emphasize the concept, rather than increase understanding.'
2) 'Animations about what is actually happening would help to reinforce the concepts involved. Only occasionally do the demos add much value to the learning experience.'
3) 'The demos keep my mind from wandering, you should keep them.'

The comments were varied and evaluation of them would be highly speculative. Opinions in the research vary on comment one above, but this idea is proposed and currently under study by chemical educators. Animations are a useful tool for several concepts, but some do not lend themselves well to animation graphics. In addition, even though the graphics staff available locally is quite skilled, some technological resources are not available at the level of this project. The final comment above emphasizes an important function of demonstrations, that of maintaining the interest and keeping a student from getting bored. Several gave suggestions for ideas on how to improve the videos in the future which will be incorporated in the General Chemistry II Video Series.

Conclusion

The demonstrations, as perceived by the students, enhanced their understanding of the concepts being presented. Visual illustration helped the students internalize and assimilate the principles. The high number of correct responses correlating the demonstration seen to the principle it illustrated show this.

Overall, utilization of the visual advantages of television for incorporation of demonstrations into videos is beneficial for understanding concepts. Demonstrations are a

valuable addition to the lecture in a video taped lesson both as a teaching tool and as a way to capture interest and break the monotony. The presentation and filming quality of these demonstrations was perceived for the most part as excellent or good. In retrospect, from viewing the demonstrations, there are ways in which they can be improved for the next video series. Pre-taping and observing background, lighting, and overall visibility is one way to ensure reactions are seen clearly on the video tape.

The explanations were adequate, yet there was some difficulty on the concepts which are difficult for even graduate students and instructors. The explanations need to be rehearsed. If still not clear, then the demonstration should be substituted with one which is more easily explained yet still illustrates the chemical principle being discussed. Clearer explanations may also help to alleviate the rewinding and watching the videos again because they were not understood the first time, and switch the reason to watching again because better understanding was gained by reviewing or just enjoyment, interest, etc..

Very few of the demonstrations were not remembered. Those demonstrations may need to exchanged in the future for more dramatic, memorable demonstrations. In addition, there were a few instances when the demonstration was remembered, but not the principle being illustrated. For the instructional side, emphasis may need to be placed on the principle being demonstrated in additional to referencing the demonstrations more often in the lecture material. The video summary could include a wrap-up highlighting the demonstrations seen in the tape and the associated principle.

There are certainly the advantages of being able to rewind and review demonstrations in the visual medium, however a distinct disadvantage is the lack of direct interface with the instructor. Because of this, demonstrations had to be very straight forward. There was no method to assist the students in drawing inferences from their observations and confirm or correct them. Critical thinking development is diminished because of the lack of direct questioning. The classroom demonstrations can compensate for this whether the demonstration is performed live, or if a video taped demonstration is shown to the students.

Obviously there needs to be additional, more comprehensive studies and analysis utilizing a control group, as well as, more in-depth questioning to accurately determine

students knowledge before and after seeing demonstrations. This would be a pre- and post-test type of situation which would require preparation and coordination.

In spite of every other advantage or disadvantage of the demonstrations in the video series, there is a most important benefit. To learn the students must pay attention, either to the lecture material or to the textbook they are reading. The demonstrations may have sparked a bit of interest and maintained or increased the attention span. They kept the lectures from being stretches of dry, boring material by breaking the monotony and possibly refocusing the students. At least with the lectures on video tape, if demonstrations and the subject material failed to stimulate the students, they could always stop the tape and come back later. This is a pure advantage over just missing or skipping class altogether.

From the results of this study, the demonstrations and video series as a whole are beneficial. They received great support from the students and more video courses like this one. Predictions are that future enrollment will increase.

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APPENDICES

APPENDIX A
RESOURCES

1. Chemistry Demonstration and Visual Aids
2. Chemistry Instruction
3. Journal of Chemical Education Computer Search Listing

CHEMISTRY DEMONSTRATION and VISUAL AID RESOURCE LIST*

1. Basic Laboratory studies in College Chemistry, 3rd Edition
Hered, William and Nebergall, William (QD45 H47 1968)

2. Chemical Demonstrations: A Sourcebook for Teachers, Vol 2., 2nd Edition
Summerlin, Lee R.' Borgford, Christie L., and Ealy, Julie B.

3. Chemical Investigations for Changing Times
Scott, Lawrence W., et al (QD45 .C45)

4. Chemistry and The Environment: a Laboratory Experience
D'Auria, John M. (QD45 D24)

5. Encounters in Experimental Chemistry
Jolly, William L. (QD43 J644)

6. General Chemistry in the Laboratory including Qualitative Analysis
Jones, W. Norton Jr., and Stubbs, Morris F. (QD45 J6)

7. Handbook of Modern Experiments for High School Chemistry
Meyer, H.A. (QD43 M48)

8. Journal of Chemical Education and Journal of Chemical Education computerized index

9. Modern Experiments for Introductory College Chemistry
Neidig, H.A. (QD45 N46)

10. On-line
The Chemical Educator http://journals.springer-ny.com/chedr

11. Chemical Demonstrations: A Handbook for Teachers of Chemistry, Vols. 1-4
Shakhashiri, Bassam Z. University of Wisconsin Press

12. Tested Demonstrations in Chemistry
Alyea, Hubert N. (QD45 J65 1965)

13. Various General Chemistry textbooks

14. Visualizing Chemistry, Investigations for Teachers
Ealy, James L., and Ealy, Julie B. (QD43 E25 1995)

* Call numbers are for the Auraria Library, Auraria Campus, Denver, Colorado.

CHEMISTRY INSTRUCTION
RESOURCE LIST*

1. American Journal of Science (Q1 A5)

2. <u>Classical Methods, Volume 1, Analytical Chemistry by Open Learning</u>
   Cooper, Derek et. al. (QD111.C78 v.1))

3. <u>Education and Teaching in Analytical Chemistry</u>
   Baiulescu, G.E. (QD75.7 B34 1981

4. <u>Efficiency in Research Development and Production: The Statistical Design and Analysis of Chemical Experiments</u>
   Davies, Leslie (QD43.D258 1993)

5. Journal of Research in Science Teaching
   Vol 31, Issue 8, Oct 94, p811 (Q181 A1 J6)

6. Journal of Chemical Education

7. Journal of College Science Teaching (Q183 U6 J68)

8. Science Education (Q1 S385)
   Vol 75, Issue 2, 1991, p215

* Call numbers are for the Auraria Library, Auraria Campus, Denver, Colorado.

Journal of Chemical Education
Resources for Demonstrations and Laboratory Experiments
MASTER LIST

A. Stoichiometry

1989-1992

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B. Thermodynamics

1989-1992

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C. Gases

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APPENDIX B

Demonstration List and Selected References

Lecture Demonstration Project

Demonstration List

1. Stoichiometry

Demo 1.1

Title: Explosive reaction of Hydrogen and Oxygen (1.42, pg 106-112, Vol 1)

Description: H_2/O_2 balloon explosion

Demo 1.2

Title: Multiple Fountain Effect with Ammonia (8.10, pg 92-95, Vol 3)

Description:

Demo 1.3

Title: Electrolytes

a. The "Standard" Orange Electrode (11.3, pg 107-110, Vol 4)

b. Conductivity and Extent of Dissociation of Acids in Aqueous Solution (8.21, pg 140-145, Vol 3)

c. Electrical Conductivity of Liquids (9.31, pg 326-328, Vol 3)

Description: Conductivity Testers

Glucose/Water, Acetic Acid, NaCl, Ammonia, tomato paste, orange or lemon, pH balanced shampoo, sports drink advertising electrolytes, vinegar, saline solution

Problem 1.4

Title: Iron and HNO_3

Description: 5 g Fe and excess HNO_3 (aq), try 6 M and 3 M

Problem 1.5

Title: 1.2 Molar Glucose solution

Description: Make 1 liter; 216 g glucose & enough water for 1 L

Problem 1.6

Title: 1.2 Molar Glucose solution

Description: Make only 140 mL; 30.24 g glucose & enough water for 140 mL

Problem 1.7

Title: 0.5 Molar Glucose solution

Description: Dilution of 1.2 M solution; 83 mL of 1.2 M diluted to 200 mL

Visual Aid 1.1

40 hot dogs and 40 buns in packages with a ratio of 4:5

Common Examples: baloney sandwich, S'mores, hot dogs/buns (film at grocery)

2. Gases

Demo 2.1

Title: State/Volume/Shape relationships

Description: Pour 50 mL of colored water from short fat beaker to tall, slender, graduated cylinder. Put a solid shape in 3 different size/shape containers and notice the shape doesn't change

Demo 2.2

Title: Balloon/Marshmallow in reduced pressure

Description: Boyles Law ($P \alpha 1/V$), need a better vacuum for balloon demo, it is too slow with aspirator (about 5 minutes); marshmallow expands for about 20 seconds, and then starts to decrease, this demo would have to be cut from the camera at about 17 seconds, see presentation suggestions in notebook

Demo 2.3

Title: Liq N_2/balloon

Description: Charles' Law ($V \alpha T$), time for this about 1-2 minutes, see presentation suggestions in notebook

Demo 2.4

Title: Marble agitator

Description: Effusion (Graham's Law)

Demo 2.5

Title: CO_2 cartridge for seltzer bottle filling balloon

Description: Boyle's Law

Visual Aid 2.1

Bowling Alley, illustrating kinetic energy of ping-pong ball, tennis ball, and bowling ball

Common Examples: soda at altitude, air bag for cars, decreasing baking soda in baking at higher altitudes, scuba divers, $KE = 1/2\ mv^2$ example running back vs lineman: KE can be same even though large size difference due to speed

3. Thermodynamics

Demo 3.1

Title: Fundamental Issues of Thermodynamics Illuminated by Conspicuous Inorganic Chemistry: Oxidation of $[Co(H_2O)_6]^{2+}$ to $[Co(H_2O)_6]^{3+}$ by Hydrogen Peroxide

Description: Thermodynamic Coupling to make a nonspontaneous reaction go; good color, pink, very dark green, blue, pink, immediate color changes; reaction time to complete 3-5 minutes

Demo 3.2

Title: Endothermic Reactions of Hydrated Barium Hydroxide and Ammonium Salts (1.3, pg 10-12, Vol 1)

Description: Endothermicity, good temperature readings

Demo 3.3

Title: Dehydration of Sugar by Sulfuric Acid (1.32, pg 77-78, Vol 1)

Description: Clear mixture turns to a black liquid and then begins to bubble as hydrogen is released and a black charcoal like product "grows" out of the beaker. Do in well ventilated area or hood.

Demo 3.4

Title: Reaction of Potassium permanganate and Glycerin (1.35, pg 83-84 , Vol 1)
Description: Exothermicity, do in hood, volcanic type reaction -- smoke and flames -- with products spattering about three feet. Needs to be done on a very heat resistant surface.

Demo 3.5

Title: Specific Heat Demo with beeswax
Description: Take 10-15 minutes to get water boiling, 15 minutes to heat metal samples, and 1-2 minutes to clearly demonstrate the specific heat

Visual Aid 3.1

Entropy of "52 card pick-up"

Visual Aid 3.2

Boiling water

Visual Aid 3.3

Book being lifted and dropped

Common Examples: marble floor-heat capacity (always feels cool), dry ice in cooling compartment of racing motorcycles, first aid hot/cold packs; Entropy-child's room spontaneously getting messy, hot sand analogy

Thermodynamics Analogy:

4. Kinetics

Demo 4.1

Title: Colorful Kinetics (Bleach demo by Kimbrough and Weaver)
Description: Performed with no difference in concentration (all colors)

Demo.2

Title: Colorful Kinetics (Bleach demo by Kimbrough and Weaver)
Description: Performed with difference in concentration;
4/20 and 1/40 bleach/water (one color, green)

Demo 4.3

Title: Lightstick (6.1, pg , Vol 2?)
Description: Temperature dependence on rate

Demo 4.4

Title: Oxidations of Luminol (2.4, pg 156-167)
Description: Catalysis, use also with $K_3Fe(CN)_6$
Alternates

1) Title: Sensitized Oxalyl Chloride Chemiluminescence (2.3, pg 153-155, Vol 1)
   Description: Chemiluminescence, multiple colors in 125mL Erlenmeyers
2) Title: Hydrogen Peroxide Oxidation of Lucigenin (2.7, pg 180-185, Vol 1)
   Description: Chemiluminescence, one or two color options, done in a condensation tube or clear downward spiral tube

Visual Aid 4.1

Title: Demonstration of Rate limiting step

Description: Glass funnels with sand in series of different flow rates representing different intermediate steps and rate limiting steps

Visual Aid 4.2

Title: Invisible Painting (8.3, pg 47-49, Vol 3)

Description: the bird picture; mention pens with same properties, film guy 4 at Larimer with magic pens

Common Examples:

Kinetics Analogy: Moving bricks by hand, wheelbarrow, or truck
Mail -regular mail vs. express service
Skiing - climbing the hill vs. towrope or lift
Airport - walking vs. moving sidewalk

5. Equilibrium

Demo 5.1

Title: Briggs-Rauscher Reaction (7.1, pg 248, Vol 2)

Description: amber/blue-black/clear/repeat; very distinct color changes

Demo 5.2

Title: Cerium Catalyzed Bromate Malonic Acid Reaction (7.2, pg 257, Vol 2) (The Classic Belousov-Zhabotinsky Reaction)

Description: red/green/blue/violet/repeat-over 30 minutes, very nice distinguishable color

Demo 5.3

Title: Chemical Equilibrium

Description: can be used to illustrate equilibrium, and allowed to run while video taping continues, then becoming a background prop, uses a Sohxlet extractor,

Demo 5.4

Title: Chicken bones in vinegar and eggs in vinegar

Description: In vinegar, or 1M acetic acid, bones become rubbery. In water, there is no change. Egg shells dissolve in vinegar leaving the membrane. Eggs feel like fragile rubber balls. The acid disturbs the calcium/hydroxide equilibrium and causes more of the calcium to come out of the bone.

Ca complex $\longleftrightarrow Ca^{2+} + 2OH^- \longrightarrow CH_3CO_2H \longrightarrow CH_3CO_2^- + H_2O$

Demo 5.5

Title: Osmosis through an egg membrane

a) Sugar water

b) Dye

Description: Dissolve egg shells with vinegar leaving membrane. Place one egg in sugar water to observe osmosis of water inside membrane going to the concentrated sugar solution. Place another egg in colored water. Color can be from methylene blue or food coloring. Osmosis of the color with leave you with

an egg with food coloring on the inside. (Placing the coloring directly on the membrane and then adding water increases the rate of osmosis.)

Demo 5.6

Title: Osmosis: Carrot in saturated saltwater

Description: Carrots in saltwater shrivel

Common Examples: Filling a bathtub

6. Atomic Structure and Periodicity

Demo 6.1

Title: Floating Penny

Description: A post-1982 penny soaked in 1M HCl has the zinc interior dissolved leaving the copper outside. The penny must first be knicked or cut to expose the Zinc interior. Two knicks and two days works best, but I couldn't get the penny to float. However, there is still a large weight difference.

Demo 6.2

Title: Dissolving Penny

Description: A pre-1982 penny(pure copper) soaked in 3M Nitric acid turns blue as it dissolves completely.

Demo 6.3

Title: Rotating rainbows: A solution in Polarized Light (9.51, pg 386-389, Vol 3)

Description: light properties, Karo syrup and polarizing film. The sugar solution rotates light and the film polarizes it.

Demo 6.4

Title: Bigger and Better Flame Tests

Description: Flame tests with the following compounds soaked in methanol on a watch glass and then ignited.

Compound	Flame Color
Sodium Chloride ($NaCl$)	yellow
Potassium Chloride (KCl)	blue/purple
Copper Chloride ($CuCl$)	green
Lithium Chloride ($LiCl$)	red

Demo 6.5

Title: Diffraction Grating with discharge tube

Description: Grating acts like a prism

Demo 6.6

Title: Analogy for Quantum numbers

Description: License plates

Demo 6.7

Title: Neon signs

Description: Film "Neon" signs

Gas	Color
Neon	reddish-orange
Argon	blue
Helium	yellowish-white

Helium-Argon orange
Neon-Argon dark lavender

Demo 6.8

Title: Things to include graphically

Description: ( ) = page in Kotz and Treichel

Molecular orbital shapes (343)
Order of filling sub-shells (365, Fig 8.7)
Atom sizes (377)
Increasing atomic radii (378)
First Ionization Energy (380)
Electron affinity (382)
Orbital box diagrams (373)

Common Examples

Automatic door openers operate on the photoelectric effect with their electric eye

7. Bonding

Demo 7.1

Title: Experimental Illustration of Lewis Dot Structures

Description: Felt or velcro board with large circles for elements, labeled, and small circles to illustrate the electrons. Use as a visual aid. Make a single, double, and triple bonded molecule.

Demo 7.2

Title: Electrolysis of Water: Color Changes and Exploding Bubbles (11.14, pg 156-165, Vol 4)

Description:

Demo 7.3

Title: Making Nylon

Description: Polymerization

Demo 7.4

Title: The Disappearing Coffee Cup

Description: "Melt" a styrofoam cup by placing it in a crystallization dish 3/4 full of acetone.

Demo 7.5

Title: Hydrogen bonding in Slime

Description: Polymerization

Common Examples

APPENDIX C

Demonstration Lists per Video Tape

Table C1 - Stoichiometry[1]			
DEMO/VISUAL AID	CONCEPT	CHEMISTRY	COMMENTS
Electrolytic Behavior	Conductivity of Ionic compounds, Use a battery operated conductivity tester	Na^+Cl^- dissociates in water to form ionic compounds, which conduct electricity	Use tomato and tomato paste, plain water, salt water, and seltzer water
Electrolytic Behavior	Conductivity of covalent compounds (or lack thereof)	Non-ionic substances do not conduct	Use isopropyl alcohol and sugar water (glucose $C_6H_{12}O_6$) with conductivity tester
Molecular Formula	Emperical vs. Molecular formula	Glucose vs Formaldehyde (CH_2O)	Display a pile of atoms and 1 molecule of glucose beside 6 molecules of formaldehyde
Exploding Hydrogen Balloon	Explosive reaction to form water, reaction rate depends on temperature	$2H_2 + O_2 \rightarrow 2\ H_2O$	Safety consideration, conduct in a room with a high ceiling
Ammonia fountain	(Problem on stoichiometry using NH_3)	Addition of water into the system causes all the ammonia gas to dissolve in a small volume of liquid (H_2O) creating a vacuum	The vacuum causes the indicator solution to be sucked into the inverted flasks. Universal indicator causes the solution to change colors.
Hot dog/Bun analogy	Balancing Equations	none (metabolism)	Buns @ 8 per pack, and Hot dogs @ 10 per pack; therefore need 5 pkgs buns and 4 pkgs hot dogs.
Problem 1.7 Illustration	Percent yield	$2\ Fe(s) + 6\ HNO_3(aq) \rightarrow 2\ Fe(NO_3)_3 + 3\ H_2$	Use excess $HNO_3(aq)$ with 5.0 g Fe
Problem 1.8 Illustration	Prepare 1.2 M solution of glucose ($C_6H_{12}O_6$)	216.0 g glucose diluted with H_2O to make 1 L	

[1] Appendix A

Problem 1.9 Illustration	Prepare 140 mL of 1.2 M solution	30.24 g glucose diluted with H_2O to make 140 mL	
Problem 1.10 Illustration	Prepare 200 mL of 0.50 M glucose solution	83 mL of 1.2 M glucose solution diluted to 200 mL	

Table C2 - Gases[2]			
DEMO/VISUAL AID	CONCEPT	CHEMISTRY	COMMENTS
Blocks	Solid shapes, shape is independent of container	N/A	
Colored Water	A liquid's shape is dependent on the shape of the container	N/A	
CO_2 cartridge filling balloon	A gas's shape and volume depent on the container	N/A	
Balloon in reduced pressure	Boyle's Law	$P \propto 1/V$, $P \times V = \text{Constant}$ $P_1V_1 = P_2V_2$	
Marshmallows in reduced pressure	Boyle's Law	$P \propto 1/V$, $P \times V = \text{Constant}$ $P_1V_1 = P_2V_2$	
Balloon in liquid nitrogen	Charles' Law	$V \propto T$, $V = \text{Constant} \times T$ $V_1/T_1 = V_2/T_2$	
Marble Agitator	Graham's Law of Effusion and Diffusion	Diffusion - thorough mixing occurs faster if molecules are smaller because velocity is larger	Effusion - Small molecules effuse into a small opening faster than large molecules
Kinetic Energy	Bowling Alley, various balls (ping-pong, tennis, bowling) are rolled with the same speed toward the pins. Only the bowling ball has enough kinetic energy to knock over any pins.	Kinetic Energy (KE) = $1/2\ mv^2$ where m equals mass and v equals velocity	At higher velocities, the tennis ball and ping-pong ball would have a great enough KE to knock over pins.

[2] Appendix A

Table C3 - Thermodynamics[3]			
DEMO/VISUAL AID	CONCEPT	CHEMISTRY	COMMENTS
Book falling to the floor	Spontaneous change, energy input required to restore to original position		Use video capabilities to show book going from the floor to the desk
Dehydration of Sugar	Spontaneous change, exothermic	$H_2SO_4 + C_{12}H_{22}O_{11} \rightarrow 12\ C + H_2SO_4 \bullet n\ H_2O$	Sulfuric acid (18 M) dehydrates sugar and becomes hydrated
Boiling water	Neg ΔG is a favored process	$H_2O\ (l) \rightarrow H_2O\ (g)$ at 100°C	
Beeswax with Al, Fe, Pb	Heat capacity $C = q/\Delta T$; temp change experienced by a body when it absorbs a certain amount of heat at constant pressure	Element Heat capacity Al .225 Fe .127 Pb .032	Al travels furthest and is the longest sample; Pb travels the shortest distance and is the shortest sample
Barium Hydroxide and Ammonium Chloride	Endothermic reaction; large increase in entropy; $\Delta G = -47.7$ kJ	$Ba(OH)_2 \bullet 8\ H_2O + 2\ NH_4Cl \rightarrow BaCl_2 \bullet 2\ H_2O\ (s) + 2\ NH_3\ (aq) + 8\ H_2O\ (l)$	Close-up of thermometer; freeze cork base to the beaker
Potassium permanganate and glycerine	Exothermic, spontaneous combustion	$14\ KMnO_4 + 4\ C_3H_5(OH)_3 \rightarrow 7\ K_2CO_3\ (s) + 7\ Mn_2O_3\ (s) + 5\ CO_2\ (g) + 16\ H_2O\ (g)$	
52-card pick-up	Entropy	Favored reaction is toward a more disordered state	

[3] Appendix A

Coupling reaction	thermodynamically unfavored reaction paired with a thermodynamically favored reaction makes the unfavored reaction go	A} $2\ Co(H_2O)_6^{2+} + 10\ HCO_3^- + H_2O_2 \rightarrow 2\ Co(CO_3)_3^{3-} + 4\ CO_2 + 18\ H_2O$ B} $2\ Co(CO_3)_3^{3-} + 12\ H^+ + 6\ H_2O \rightarrow 2\ Co(H_2O)_6^{3+} + 6\ CO_2$ X} Co^{2+} (pink) $\rightarrow Co^{3+}$ (blue) Y} $10\ HCO_3^- + 10\ H^+ \rightarrow 10\ CO_2 + 10\ H_2O$ T} $2\ Co(H_2O)_6^{2+} + 10\ HCO_3^- + H_2O_2 + 12\ H^+ \rightarrow 2\ Co(H_2O)_6^{3+} + 10\ CO_2 + 12\ H_2O$ C} $2\ Co(H_2O)_6^{3+} + H_2O_2 \rightarrow 2\ Co(H_2O)_6^{2+} + 2\ H^+ + O_2$	A} pink to green B} green to blue X} nonspontaneous Y} spontaneous T} total reaction C} blue to pink H_2O_2 oxidizes and reduces

Table C4 - Kinetics[4]			
DEMO/VISUAL AID	CONCEPT	CHEMISTRY	COMMENTS
Bleach Demo - with Green, Yellow, and Blue Food coloring	kinetics of bleach action		The yellow color disappears rapidly, the blue color takes several hours. Since green is a combination of yellow and blue, the green rapidly changes to blue, and then takes a few hours for that color to disappear.
Bleach demo - with all green and varying concentration of bleach solution	The more concentrated bleach solution causes the yellow color in the green dye to disappear more rapidly.		
Invisible painting	Basic solution causes various colors to appear on seemingly white paper.	0.01 M NaOH solution sprayed on blotter paper painted with indicator causes a color to appear.	Colors fade after a few minutes, but can be renewed with more basic spray.
Sand demo	Rate limiting step	A plug in one of the funnels cases the flow of sand to slow, thus limiting the overall reaction.	Show two sets of funnels, one with a rate limiting step and one without.
Lightstick demo	temperature affects the rate of reaction (i.e. the intensity of the glow) Energy is transferred to the dye, the excited dye emits light as it returns to its ground state	Incr. temp, incr. reaction rate, stick glows brighter; Decr. temp., decr. reaction rate, stick dims phenyl oxalate ester + $H_2O_2 \rightarrow$ 2 CO_2 + 2 phenol Dye $\rightarrow$ Dye* $\rightarrow$ Dye + $h\nu$	Do not immerse in hot water bath too early or the reaction may go to completion and "burn" out before it is shown; the lightstick in the ice bath may be started at any time

[4] Appendix A

Luminol Demo	Oxidation of luminol causes excited molecules which glow when they return to ground state	Bright blue emission produced by chemiluminescense of luminol (3-aminophthalhydrazide)	Lights must be dimmed to see the glow

Table C5 - Equilibrium[5]			
DEMO/VISUAL AID	CONCEPT	CHEMISTRY	COMMENTS
Belousov-Zhabotinsky Reaction	competing equilibria; cerium-catalyzed bromate malonic acid reaction	Lots	clock reaction; blue - green - purple - red (repeat)
Chicken bones and egg with no shell	Acetic acid in H_2O upsets equilibrium; Ca dissolves into solution	Ca complex $\leftrightarrow Ca^{2+} + 2OH^- \rightarrow$ $CH_3CO_2H \rightarrow CH_3CO_2^- + H_2O$	chicken bones soaked in vinegar become flexible with the loss of calcium, the egg shell dissolves leaving only the membrane
Briggs-Rauscher	Competing equilibria		clock reaction (Bronco rxn); orange - blue - clear (repeat)
Osmosis demo	osmosis from high concentration to low concentration	carrots shrivel in saturated salt water; dye goes from solution through the egg membrane to color the inside of the egg	take colored egg out of colored water and put into clear water, watch reverse osmosis of dye from egg to the water
Soxhlet demo	equilibrium between low temp, pink, octahedral Co^{2+} and high temp, blue, tetrahedral Co^{3+}	$CoCl_2 + NaCl + H_2O \rightarrow$ $CoCl(H_2O)_5^+ + Cl^- + NaCl$ $\rightarrow$(heat) $CoCl_2(H_2O)_2 + 3\ H_2O + Na^+Cl^-$	

[5] Appendix A

Table C6 - Atomic Structure & Periodicity[6]			
DEMO/VISUAL AID	CONCEPT	CHEMISTRY	COMMENTS
Polarizing filter with corn syrup	Corn syrup rotates light; use 2 different pathlengths	the longer the pathlength, the more colorsof the spectrum	One polarizing filter is cut into triangles with polarization direction parallel to the length of the triangle, assemble the triangles into a circle, tape together, minimizing tape coverage. One filter is above the syrup container, one below. Rotate one filter to "rotate the rainbow". Use a black piece of paper with a hole cut in it to minimize excess light from the overhead.
Flame test	salts give off different colors of light as molecules are excited	place a pile of salt (KCl, NaCl, CuCl, LiCl) on a watch glass, soak with ethanol and ignite to see characteristic colors	Use ethanol not methanol. Methanol burns too hot and tends to cause the watch glasses to shatter
Line spectra	diffraction grating over camera lens, look at emission spectra of gas discharge tubes		
Morry's Neon	use diffraction grating to look spectra of the reconditioned "neon" signs		

[6] Appendix A

License plate analogy	quantum numbers		specific set of numbers specifies distinctly an atom
Penny demo Post-1982 penny	only copper on the outside	In 5 M HNO_3, the outside dissolves, leaving a zinc inner core (when removed in time) In 1 M Hcl, notches cut in penny to the core allow the core to dissolve and the copper outside remaining intact	
Penny demo Pre-1982 penny	Whole penny is copper	In 5 M HNO_3, the penny completely dissolves; if caught in time, a "ghost" of a penny can be made which is see through	To show the difference in the pennies, show the mass of the pennies before and after acid dissolution

Table C7 - Bonding[7]			
DEMO/VISUAL AID	CONCEPT	CHEMISTRY	COMMENTS
Illustration of Lewis Dot Structures	Felt board to show atoms and electrons becoming molecules and bonds		
Electrolysis of water	Leads hooked up to a power supply and to the solution cause the water to be electrolyzed	The side of the apparatus with twice as much gas evolved is the H_2 side, the other is O_2	
Making Nylon	bonding, polymerization		
Disappearing coffee cup	Acetone dissolves styrofoam		Squirt acetone over a styrofoam cup and watch it disappear into a pile of goo
Bonding in slime	polymerization	slime is a highly cross-linked polymer which is fluid in nature	

[7] Appendix A

Table C8 - Demos Omitted[8]			
DEMO	CONCEPT (Tape)	CHEMISTRY	COMMENTS
Traveling Waves of Color	(Stoichiometry)		tested, didn't work well, not visual enough
Heat of Dilution of Sulfuric Acid	(Thermodynamics)	H_2SO_4 (conc) + H_2O → H_2SO_4 (dilute)	tested, worked, not visually appealing
Spontaneous Combustion of White Phosphorus	(Thermodynamics)		didn't test, safety
Ammonium Dichromate Reaction	(Thermodynamics)		didn't test, safety
Thermite Reaction	(Thermodynamics)		didn't test, safety
A spontaneous exothermic reaction between two solids	exothermicity (Thermodynamics)		duplicate concept
How diapers work	(Kinetics)		didn't test, proper materials not available
Infl. of Concentration on reaction rate	Sodium sulfite solution, KIO_3 solution, HCl; time until appearance of deep blue color, vary amount of KIO_3 solution; (Kinetics)	KIO_3 + Na_2SO_3 + starch + HCl →	tested, didn't work properly, demo omitted didn't get any color change
Dissolution of tin in solutions of iodine	(Kinetics)		tested, didn't work, couldn't distinguish any mass loss

[8] Appendix A

Infl. of temp. on reaction rate	temp varied 25 -45 °C, note time until disappearance of color (Kinetics)	Oxalic acid + $KMnO_4$ in 1.0M H_2SO_4	tested, worked, omitted due to safety considerations
Infl. of catalyst upon rxn rate	test for liberation of oxygen (Kinetics)	$KCl + MnO_2 \rightarrow O_2$	tested, didn't worked
Complexes of Silver Iodide	reversibility, calculations possible (Equilibrium)		tested, worked, not visually distinguishable on camera
Chromate-Dichromate Rxn	(Equilibrium)		didn't test, safety
CO_2 & Limewater $\{Ca(OH)_2\}$	white precipitate (calcium carbonate) (Equilibrium)	$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$	tested, worked, not visual enough, too time dependent
Cobalt Demo - Chloro & Thiocyanato complexes	(Equilibrium)	$CoCl_2$ (aq) + HCl (conc) $\rightarrow$ blue solution (tetrahedral) + $H_2O \rightarrow$ pink solution (octahedral) + HCl $\rightarrow$ blue solution $CoCl(H_2O)_5^+$ (aq) + Cl^- (aq) $\rightarrow$ $CoCl_2(H_2O)_2$ (aq) + 3 H_2O	Duplicate concept pink to blue solutions

APPENDIX D

Student Survey

Survey for UCD Extended Studies General Chemistry I Students

This study is being conducted as part of my Master's Degree Project. It is designed to evaluate the effectiveness and usefulness of the demonstrations in the videos. This survey should only take about 15 minutes to complete. Your honesty and thoroughness in responses is appreciated. All surveys will remain confidential and anonymous. Your valuable input will help improve the videos for the General Chemistry II Extended Studies Course.

Thank you,
Kristen R. Kull

INSTRUCTIONS: Please mark one or more of the boxes which apply. If you need additional space for an explanatory response, feel free to use the space between the questions or the reverse of this sheet.

1. Overall I thought the demos were:

☐ a valuable addition to the videos with respect to understanding the concepts.

☐ fun and interesting but not necessary for my understanding.

☐ interesting but distracted me from concentrating on the lecture material.

☐ a waste of time and videotape.

2. How interesting or valuable were the demonstrations:

☐ I found the videotaped demos were **as or more** interesting/valuable than live demonstrations because I could see them better up close than in a lecture hall.

☐ I found the videotaped demos were **as or more** interesting/valuable than live demonstrations because I could rewind them and watch them again.

☐ I found the videotaped demos were **less** interesting/exciting/valuable than live in-class demos because____.

☐ I have never seen lecture demonstrations in a science class and cannot compare them to the video demos.

3. I found the presentation and film quality of the videotaped demos:

- ☐ excellent.
- ☐ good.
- ☐ fair.
- ☐ poor.

4. Overall I found the explanations that accompanied the demos to be:

- ☐ thorough.
- ☐ adequate.
- ☐ lacking depth.
- ☐ inadequate because ______________________________.

5. I rewound the tape and watched demos again:

- ☐ often.
- ☐ occasionally.
- ☐ never (skip to # 7).

6. I rewatched demos because:

- ☐ I thought they were neat.
- ☐ I found it helped me to understand the principles the demos illustrated.
- ☐ I usually/sometimes did not understand them the first time through.

7. Which tapes have you watched all or part of?

____

8. Of those tapes, which was your favorite demo(s)?

____

9. Do you remember what principle it illustrated? (Please state principle)

____

OPINIONS ON SPECIFIC DEMONSTRATIONS IN THE GASES AND THERMODYNAMICS VIDEO TAPES

10. Opinions about the **expanding balloon in reduced pressure** *on Video # 2.*

☐ I don't remember the demo.

☐ I don't remember what principle the demo illustrated.

☐ I understood the principle before the demo illustrated it.

☐ I understood the principle **better** before the demo illustrated it because the demo confused me.

☐ I found that the demo helped me to understand the principle better.

☐ I did not understand the principle until I saw the demo.

☐ I had seen the demo before this video.

11. Opinions about the **expanding marshmallows in reduced pressure** *demonstration on Video demonstration # 2.*

☐ I don't remember the demo.

☐ I don't remember what principle the demo illustrated.

☐ I understood the principle before the demo illustrated it.

☐ I understood the principle **better** before the demo illustrated it because the demo confused me.

☐ I found that the demo helped me to understand the principle better.

☐ I did not understand the principle until I saw the demo.

☐ I had seen the demo before this video.

12. Opinions about the **shrinking balloon in liquid nitrogen** *demonstration on Video # 2.*

- [ ] I don't remember the demo.
- [ ] I don't remember what principle the demo illustrated.
- [ ] I understood the principle before the demo illustrated it.
- [ ] I understood the principle **better** before the demo illustrated it because the demo confused me.
- [ ] I found that the demo helped me to understand the principle better.
- [ ] I did not understand the principle until I saw the demo.
- [ ] I had seen the demo before this video.

13. Opinions about the **marble agitator** *demonstration on Video # 2.*

- [ ] I don't remember the demo.
- [ ] I don't remember what principle the demo illustrated.
- [ ] I understood the principle before the demo illustrated it.
- [ ] I understood the principle **better** before the demo illustrated it because the demo confused me.
- [ ] I found that the demo helped me to understand the principle better.
- [ ] I did not understand the principle until I saw the demo.
- [ ] I had seen the demo before this video.

14. Opinions about the **CO_2 cartridge filling the balloon** *demonstration on Video # 2.*

- [ ] I don't remember the demo.
- [ ] I don't remember what principle the demo illustrated.
- [ ] I understood the principle before the demo illustrated it.
- [ ] I understood the principle **better** before the demo illustrated it because the demo confused me.
- [ ] I found that the demo helped me to understand the principle better.

20. Opinions about the **52-card pick-up** *demonstration on Video # 3.*

☐ I don't remember the demo.

☐ I don't remember what principle the demo illustrated.

☐ I understood the principle before the demo illustrated it.

☐ I understood the principle **better** before the demo illustrated it because the demo confused me.

☐ I found that the demo helped me to understand the principle better.

☐ I did not understand the principle until I saw the demo.

☐ I had seen the demo before this video.

21. In order to understand the chemistry background of the students, please provide the following information:
Previous Chemistry Courses

☐ High School Chemistry

Number of years ago: ☐ 1-5 ☐ 6-10 ☐ 11-15 ☐ 16+

☐ College Chemistry

☐ Completed

☐ Started but did not complete, withdrew after ______ weeks.

Number of years ago: ☐ 1-5 ☐ 6-10 ☐ 11-15 ☐ 16+

Other related courses (please list): ____

____

Please include any additional remarks or comments regarding any aspect of the video lectures and demonstrations.

____

____

____

____

____

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APPENDIX E

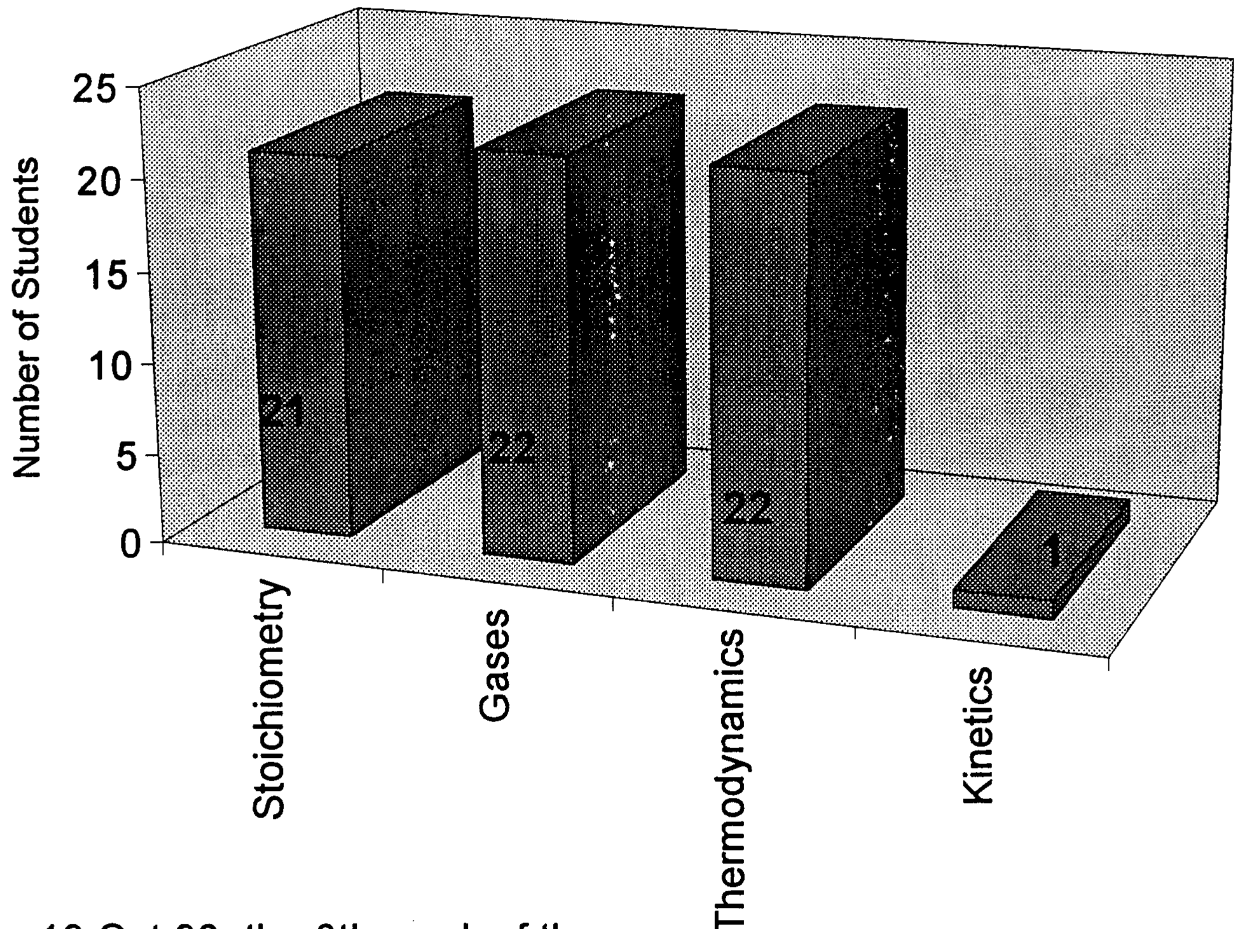
Survey Results

RESULTS

Date Survey Given:
October 19, 1996
N = 22

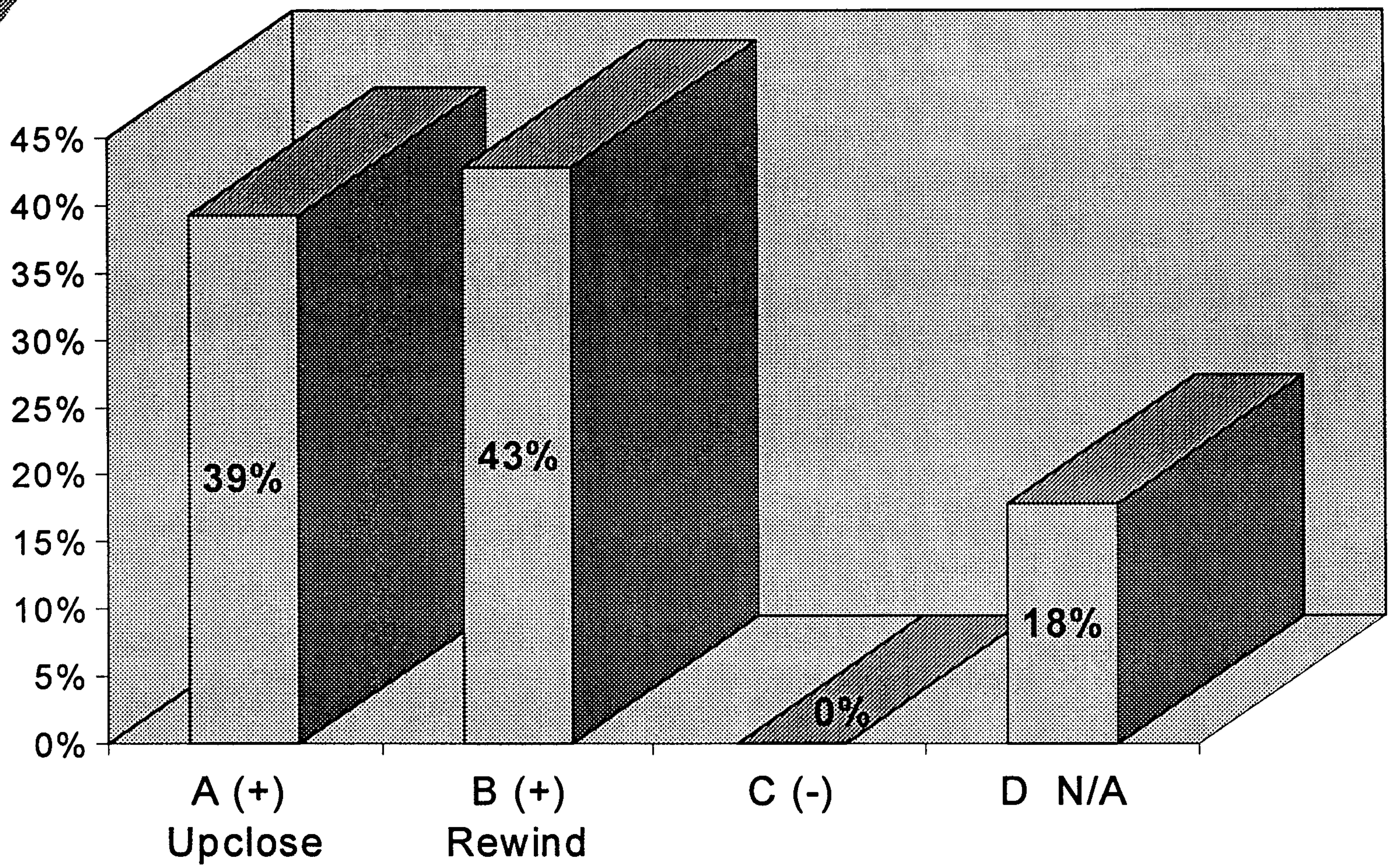
Date Survey Given: October 19, 1996 N = 22	Number of Years Ago				
	1-5	6-10	11-15	16+	N/A
Students completing High School Chemistry 19 (86%)	3	5	4	7	0
Students with previous College Chemistry Course 10 (45%) Completed course 7 (32%)	5	1	0	2	2

VIDEO TAPES VIEWED

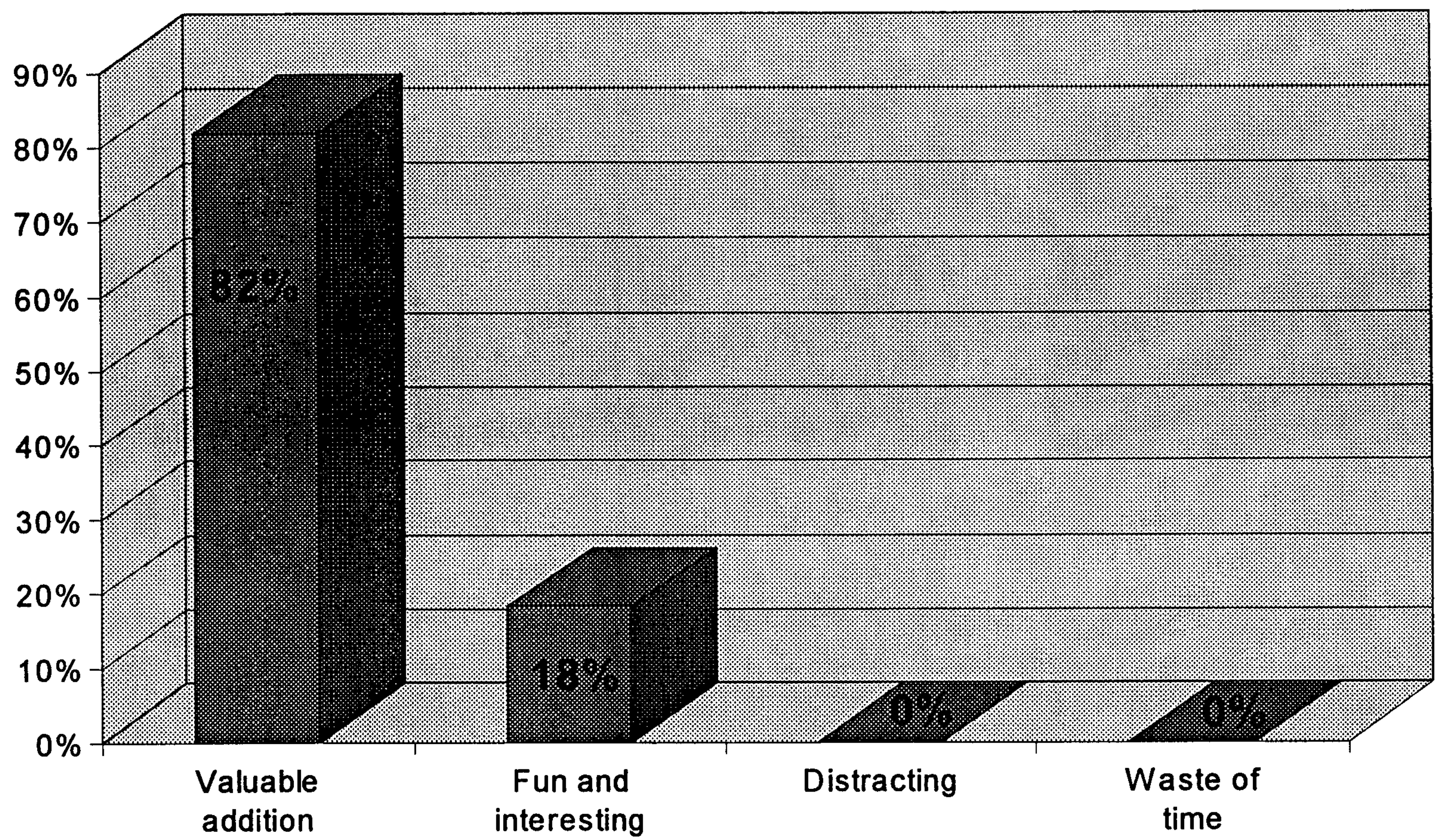


(Survey given 19 Oct 96, the 8th week of the semester when tapes 5-7 not available)

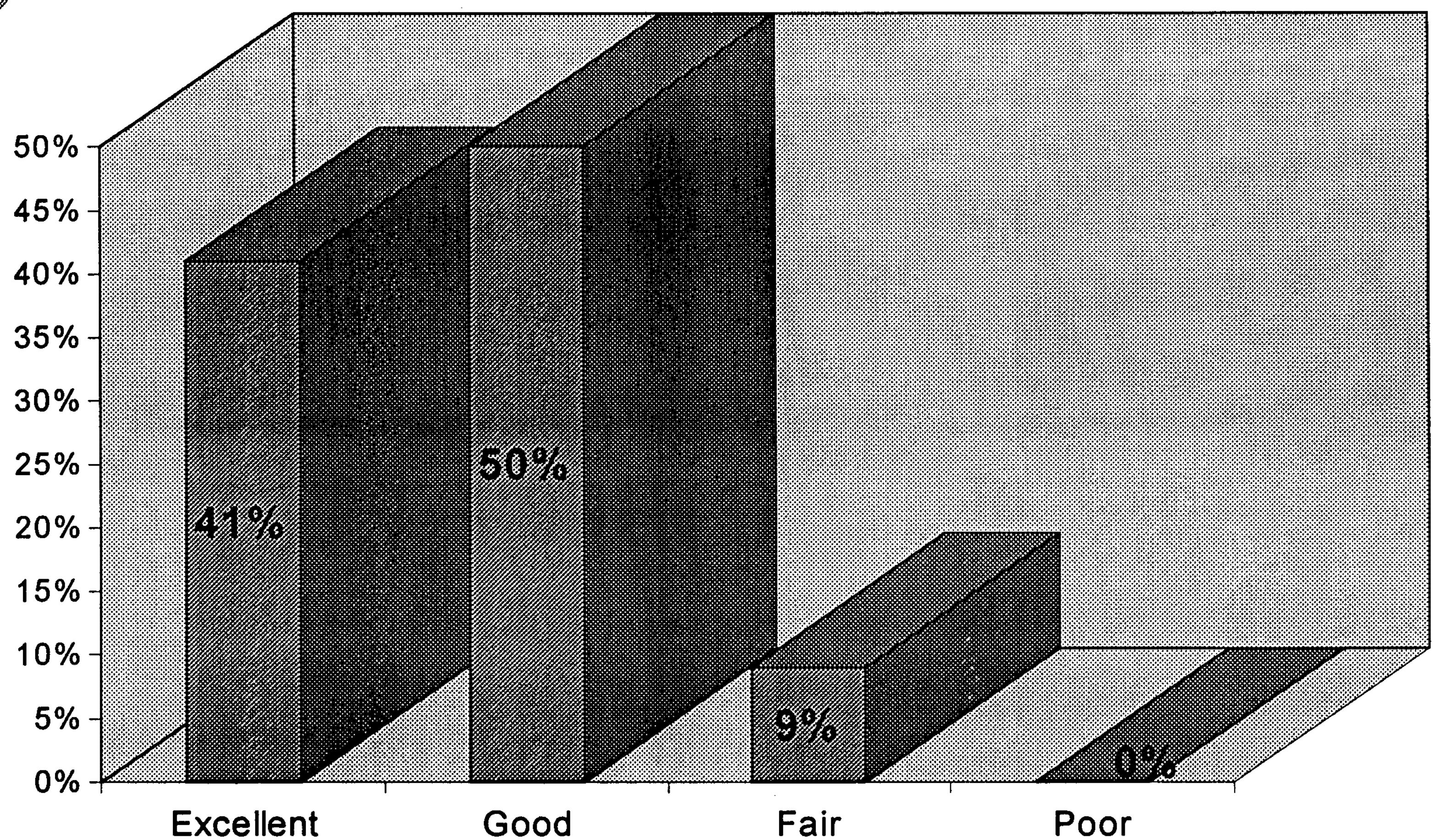
How interesting or valuable were the demonstrations with respect to lecture demonstrations?



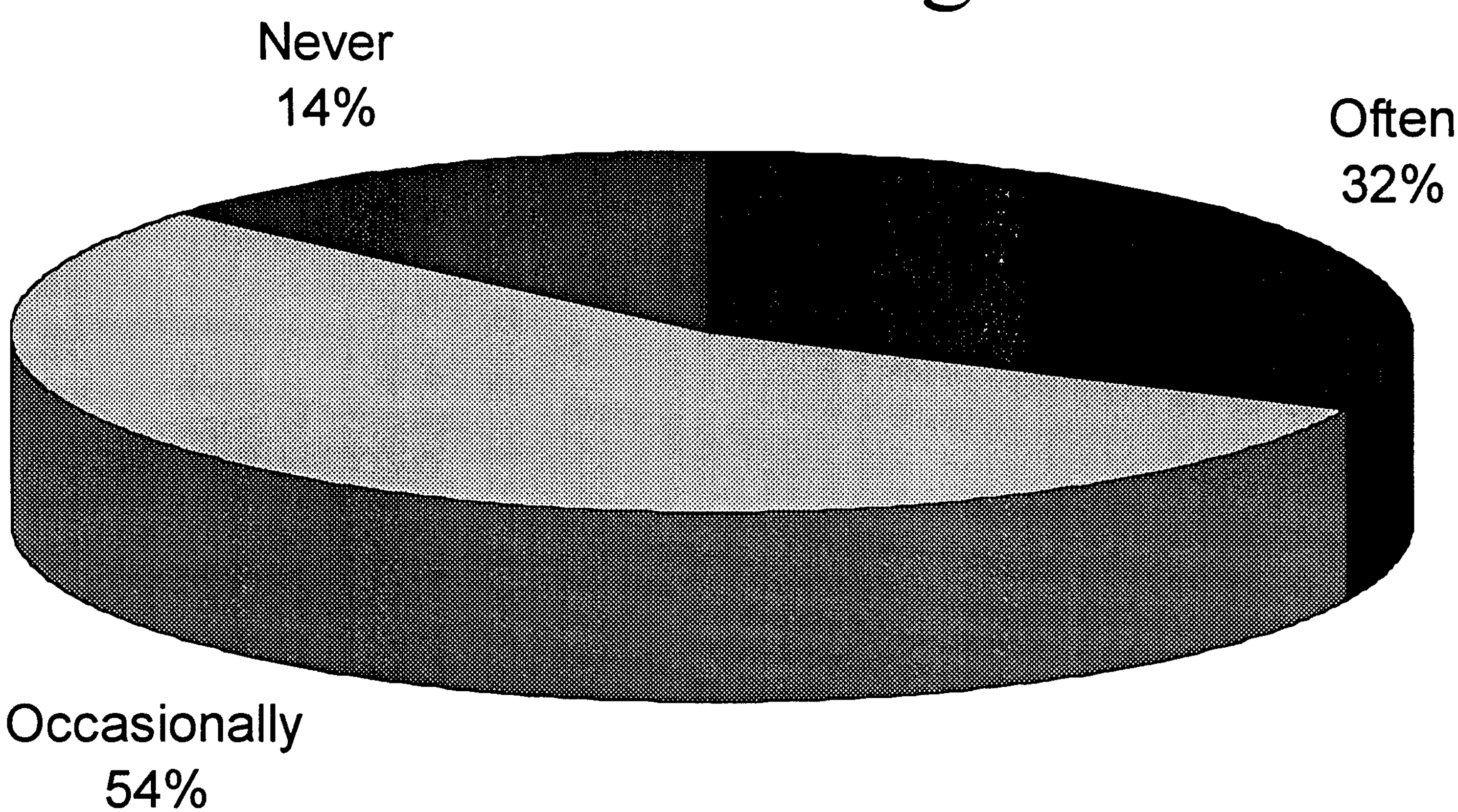
Overall, I thought the demos were:



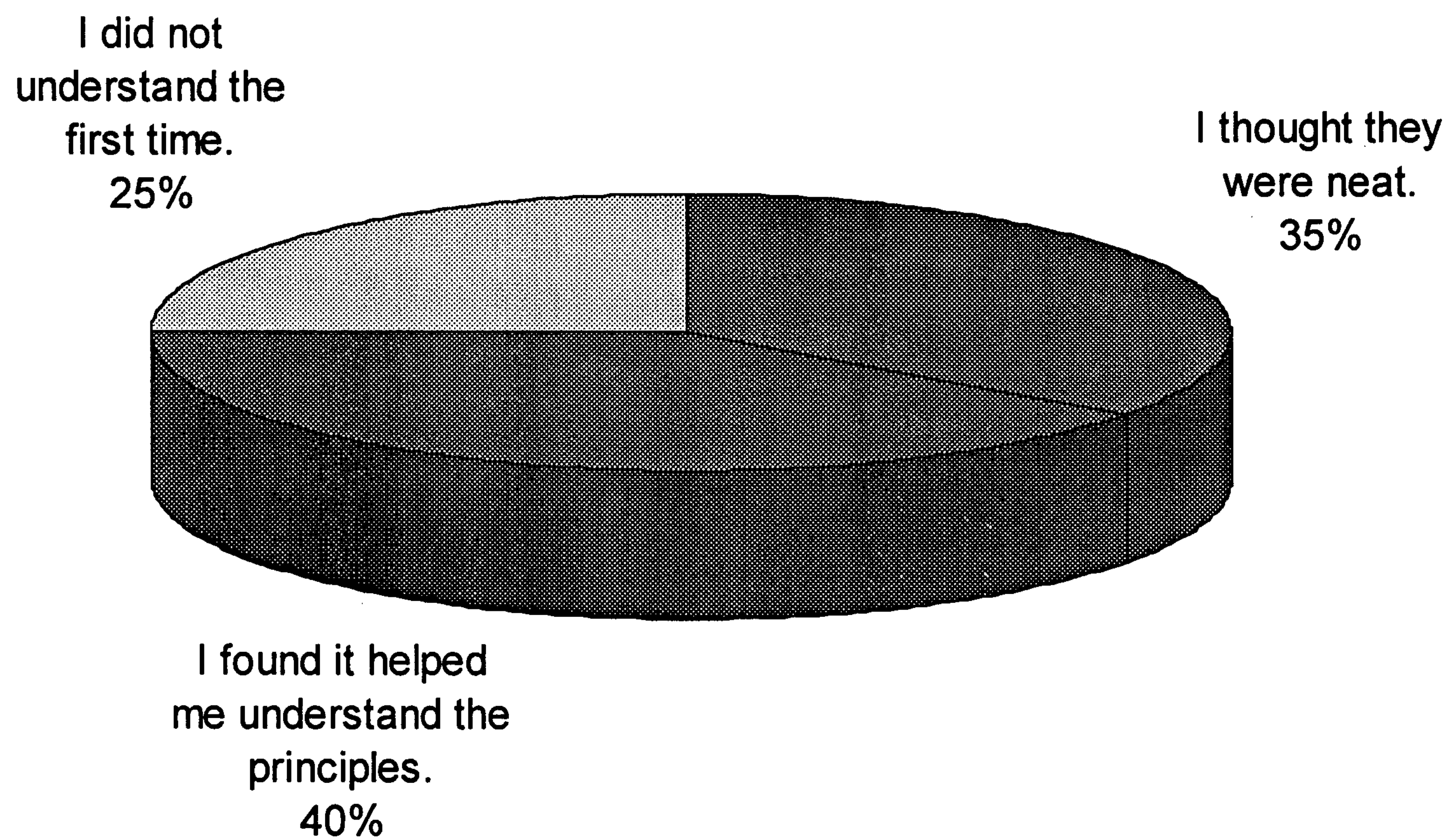
The presentation of the demos was:



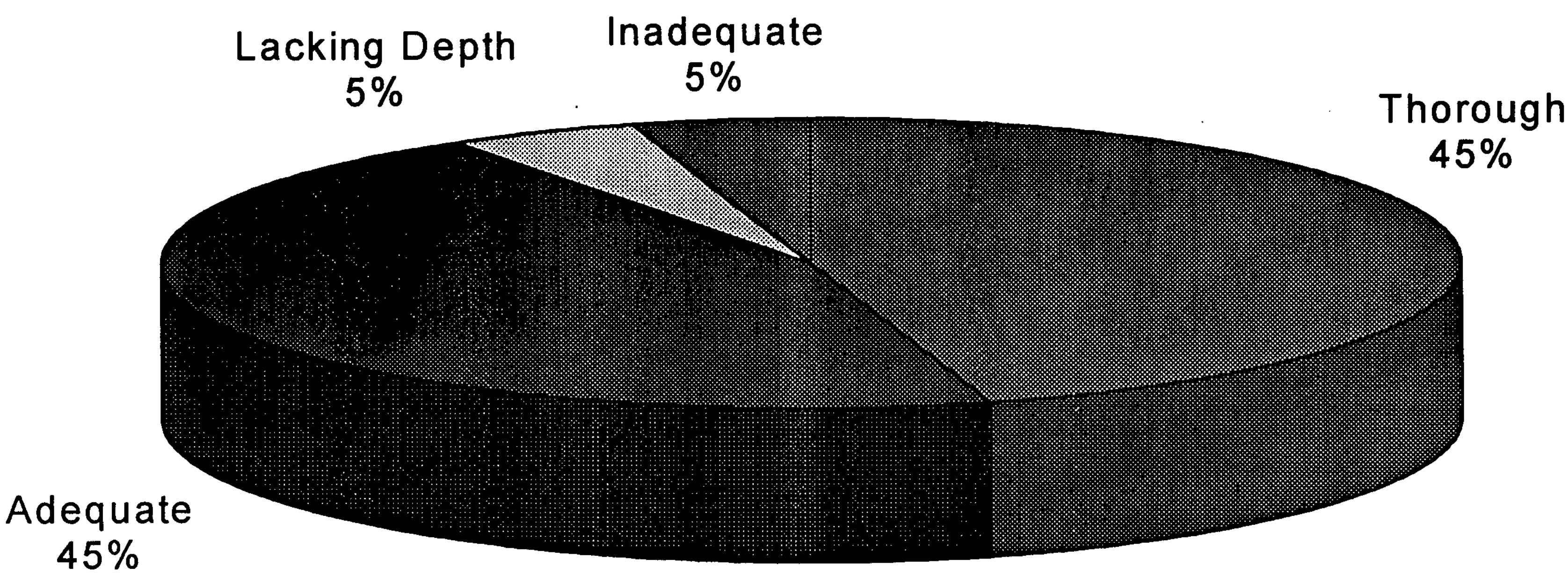
I rewound the tape and watched the demos again:



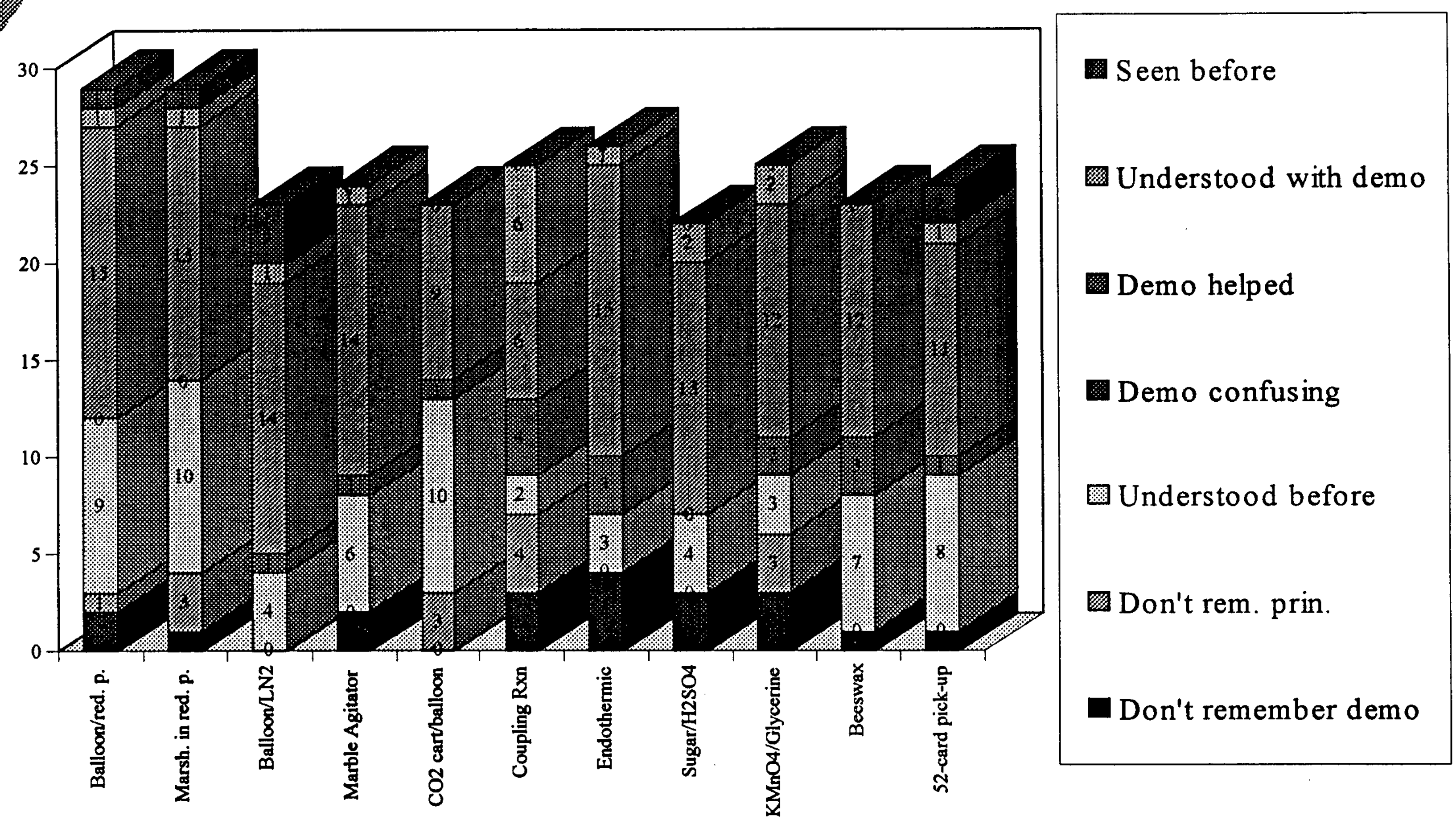
I re-watched the demos because:



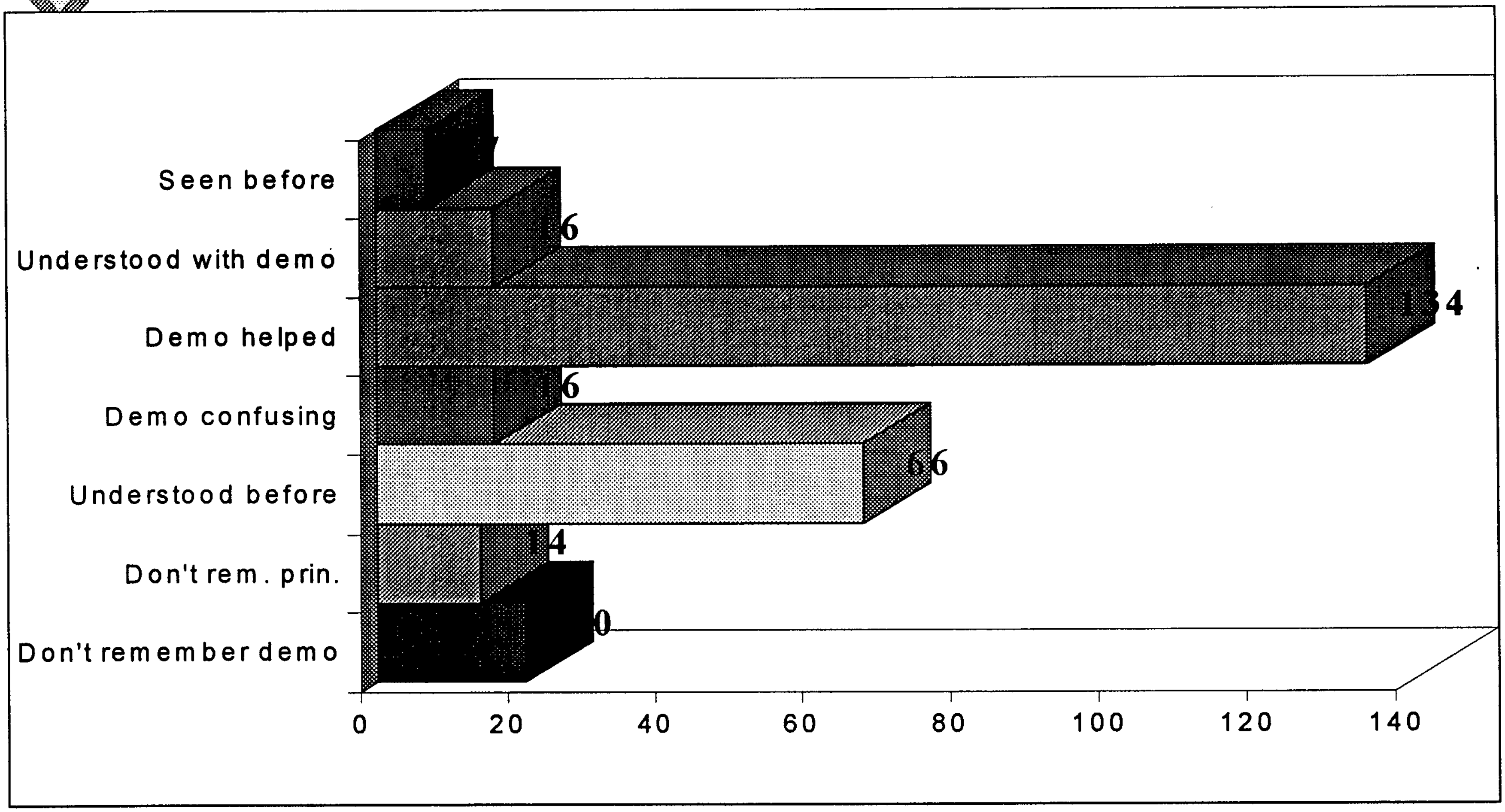
I found the explanations to be:



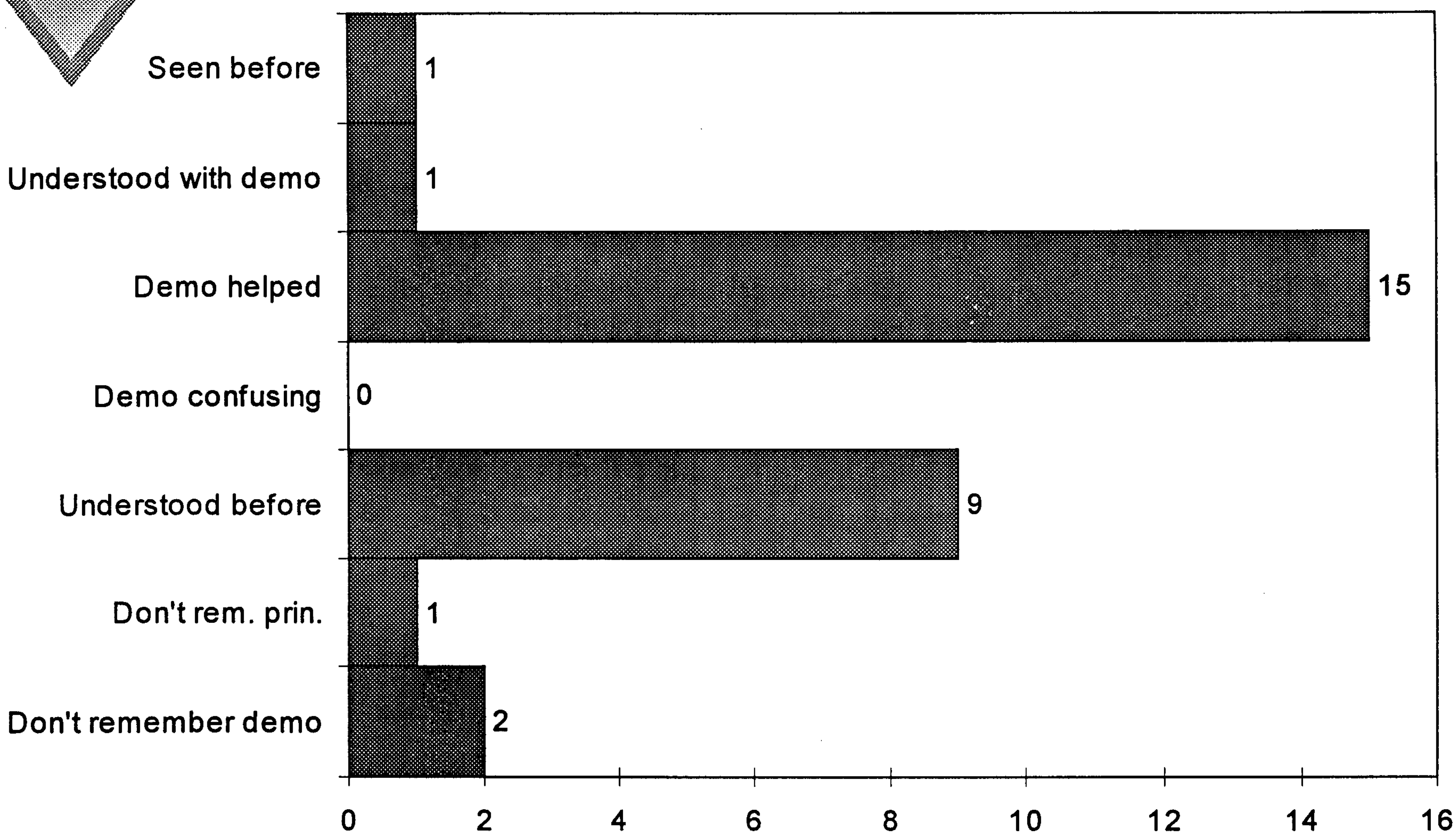
Student response per demo



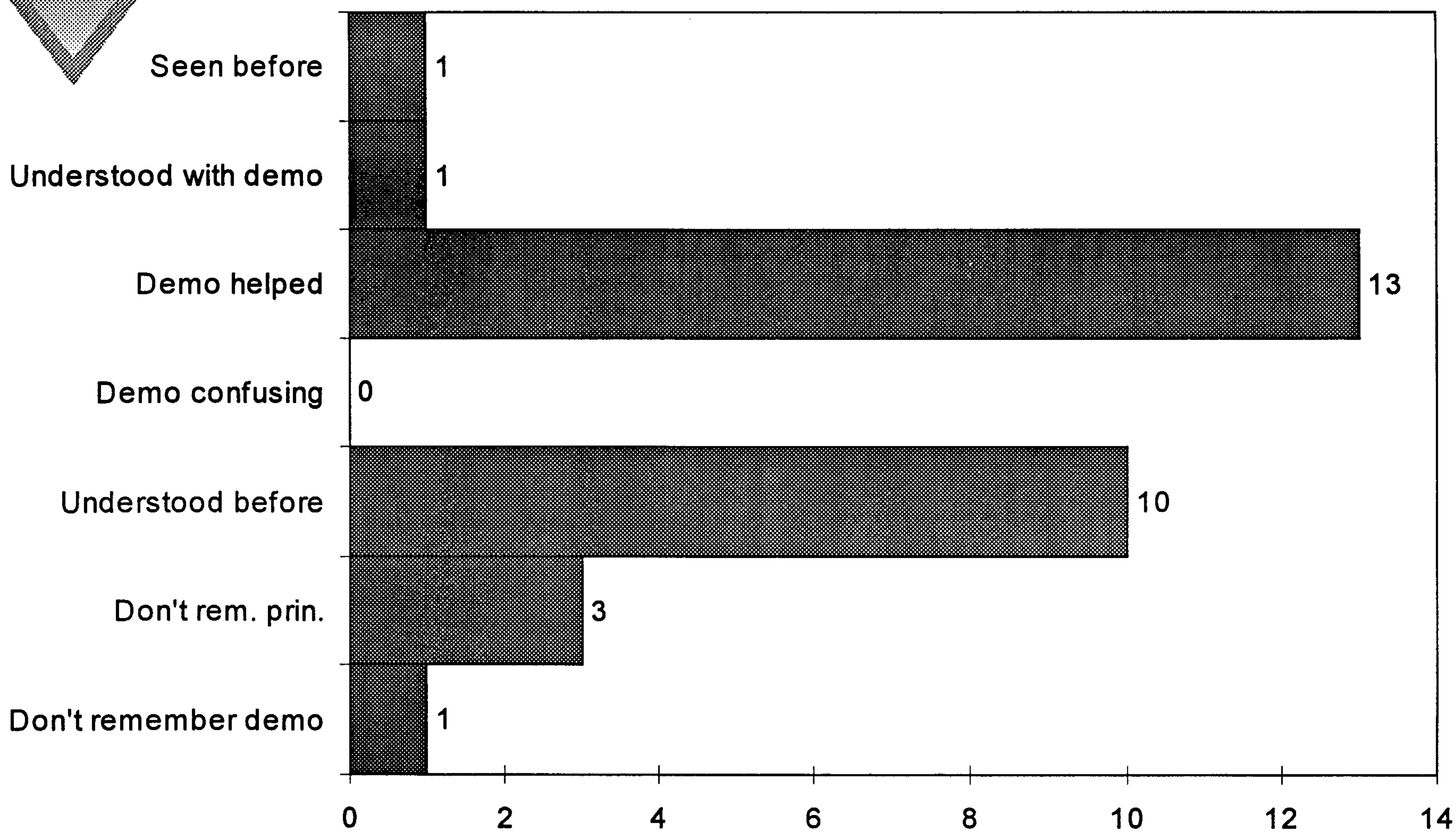
Opinions about the DEMOS in Videos 2 & 3



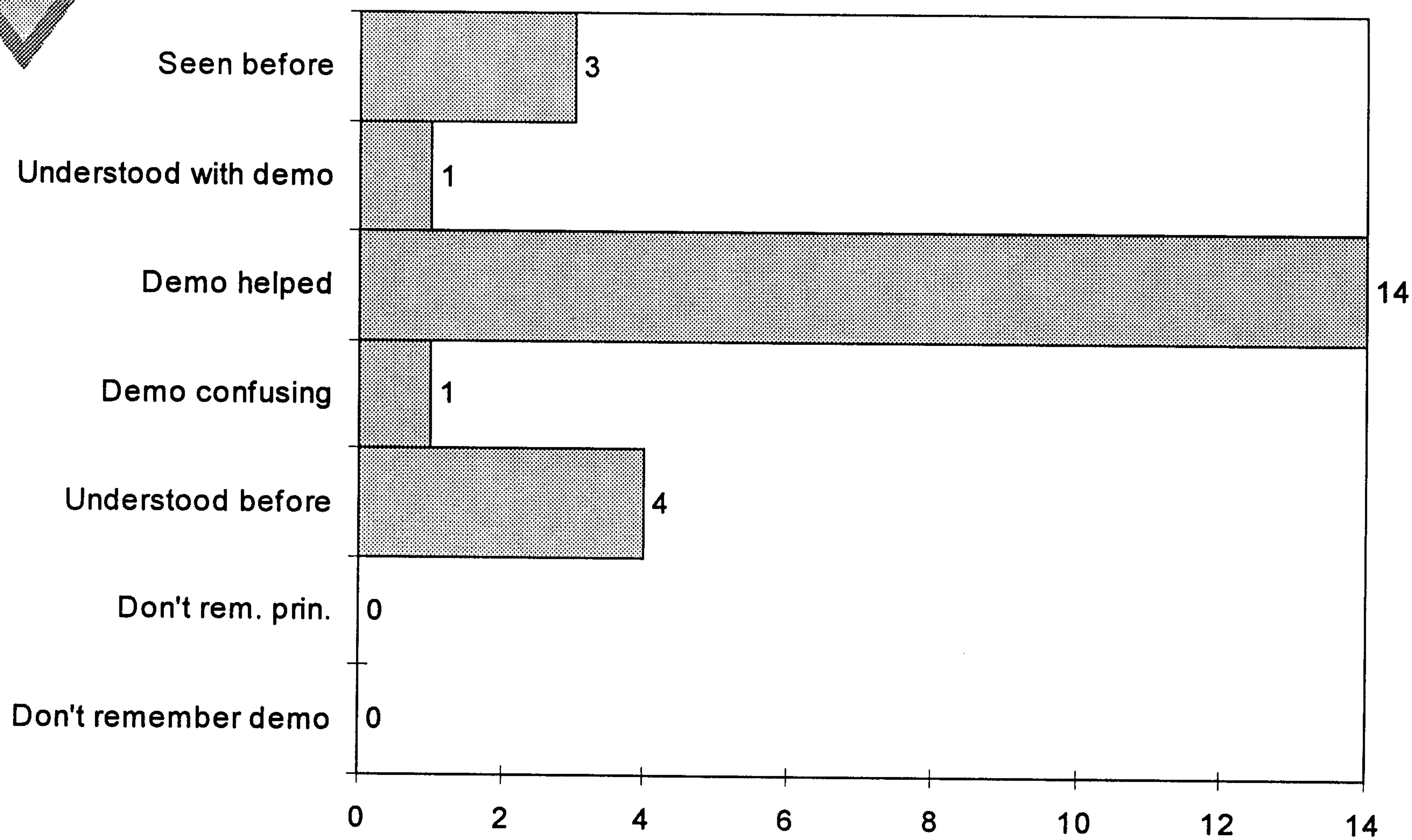
Expanding balloon in reduced pressure



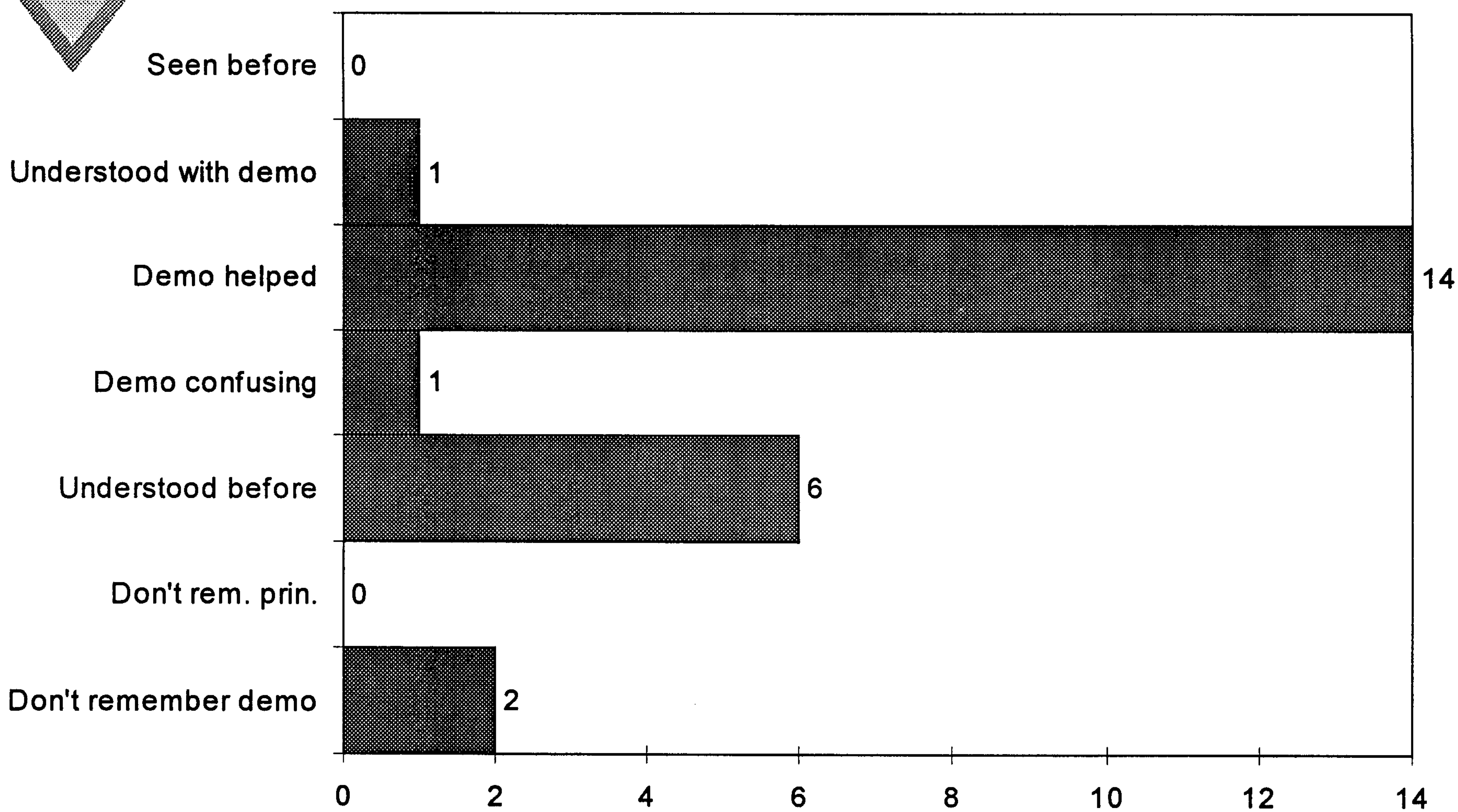
Expanding marshmallows in reduced pressure



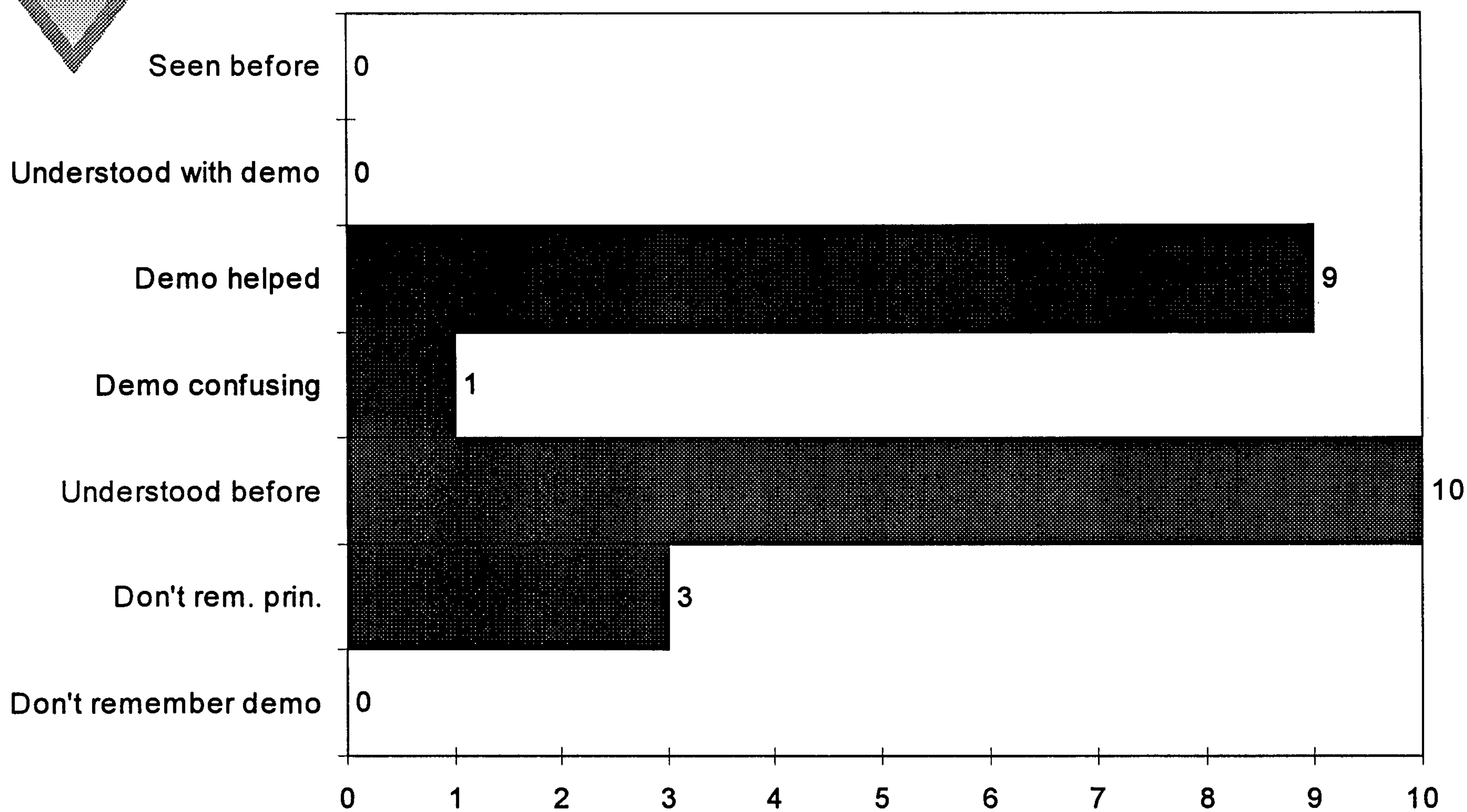
Shrinking balloon in liquid nitrogen



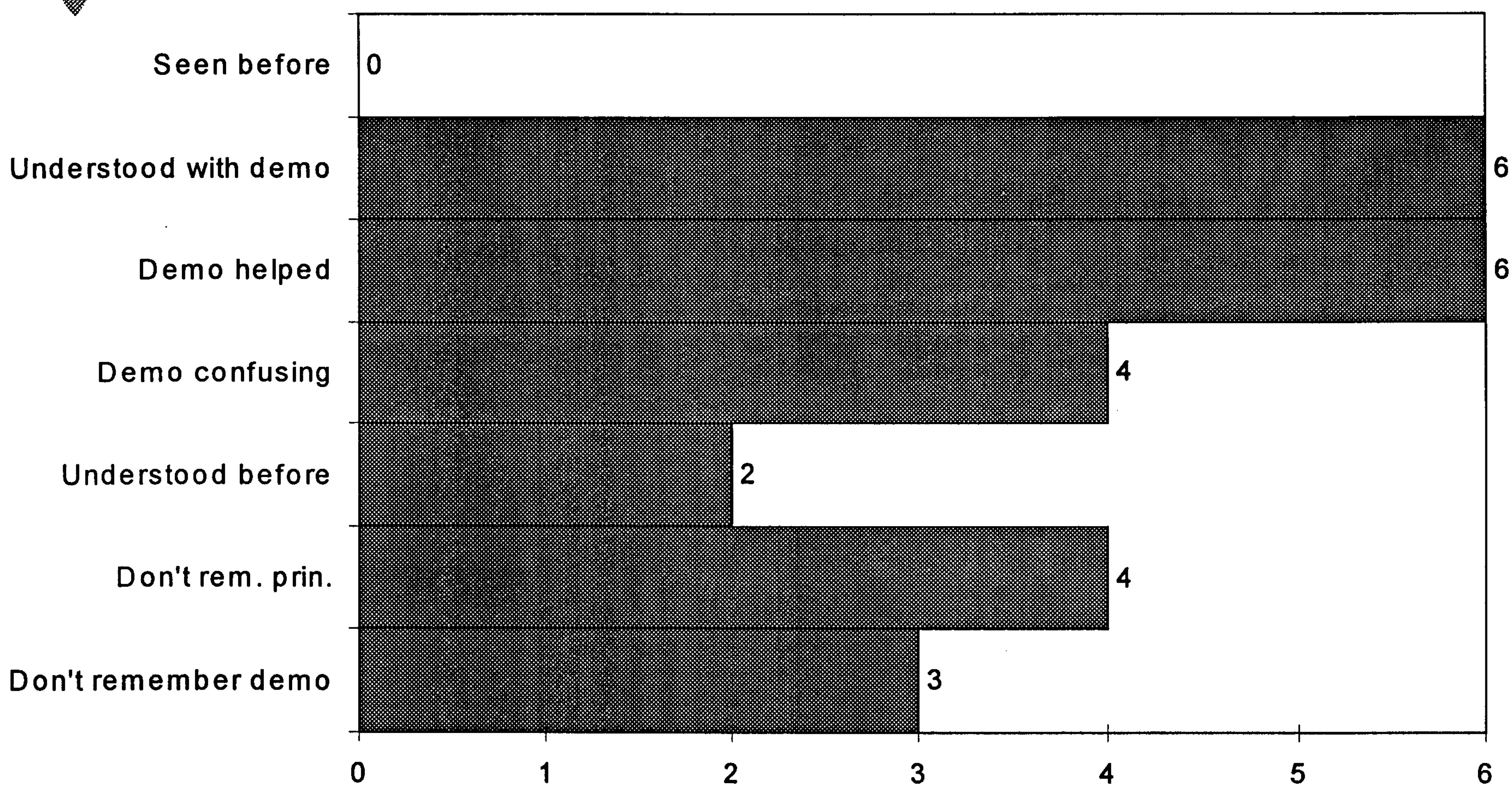
Graham's Law of Effusion and Diffusion



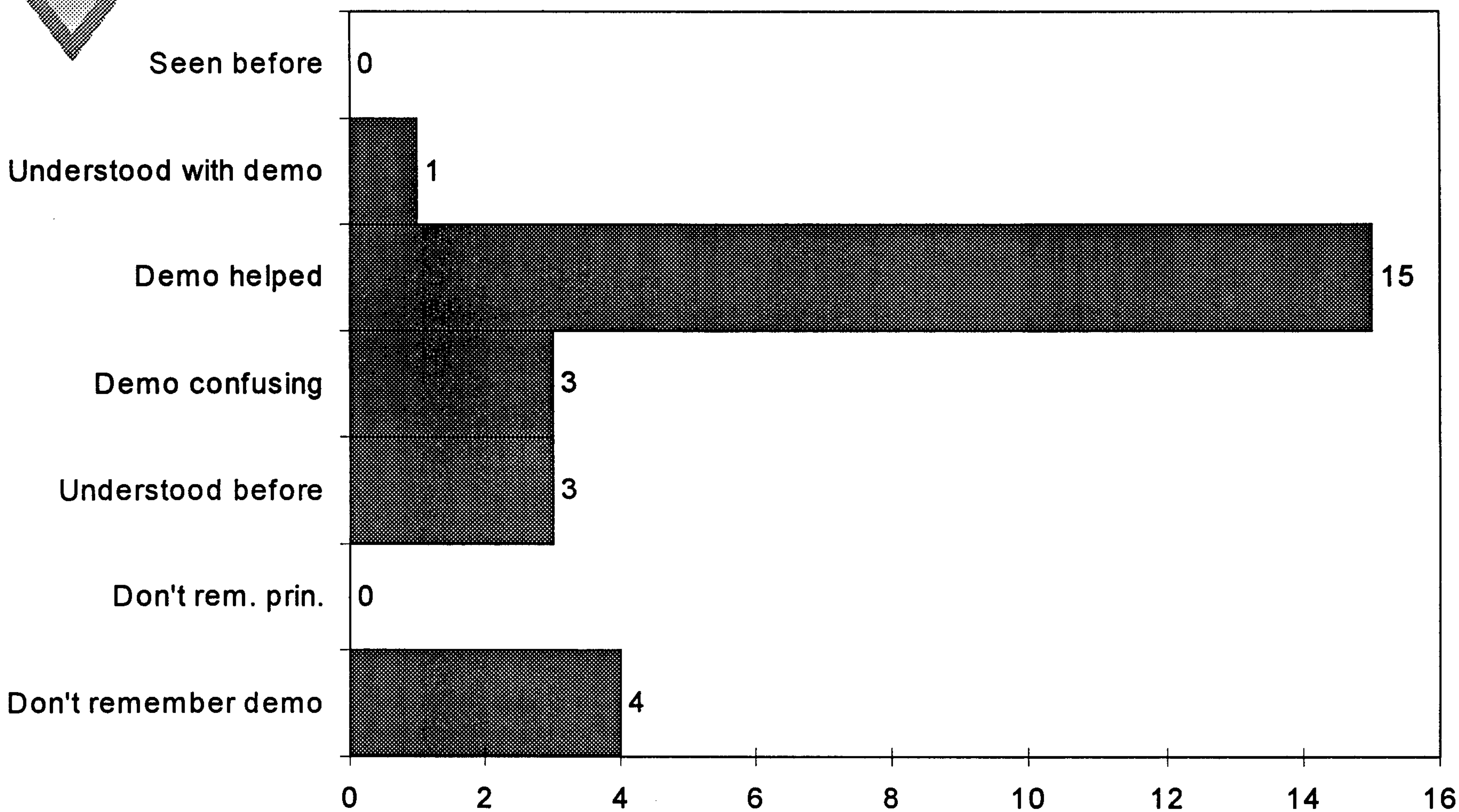
CO_2 cartridge filling a balloon



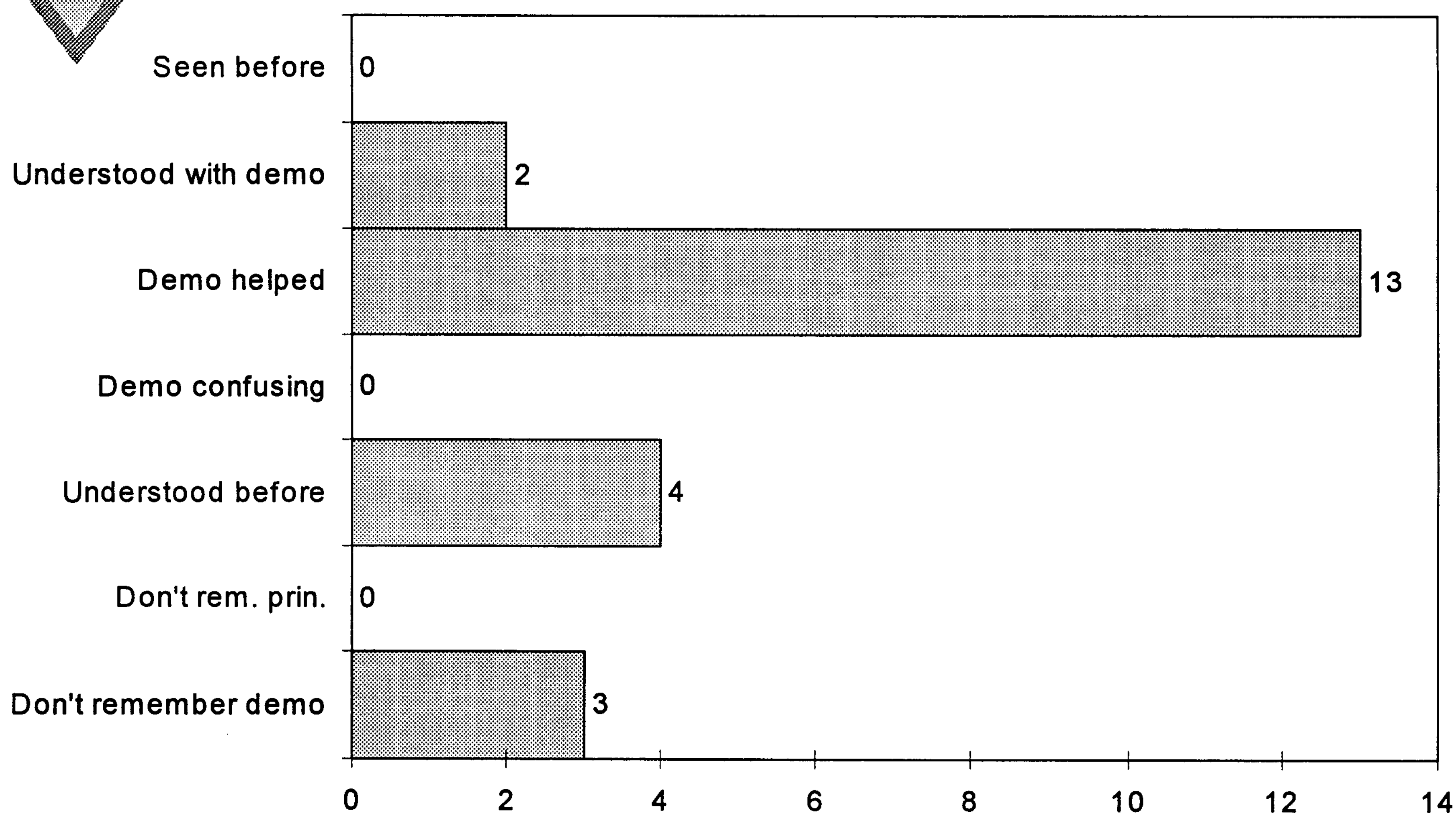
Thermodynamic coupling reaction - Most Confusing & Best Understanding Gained



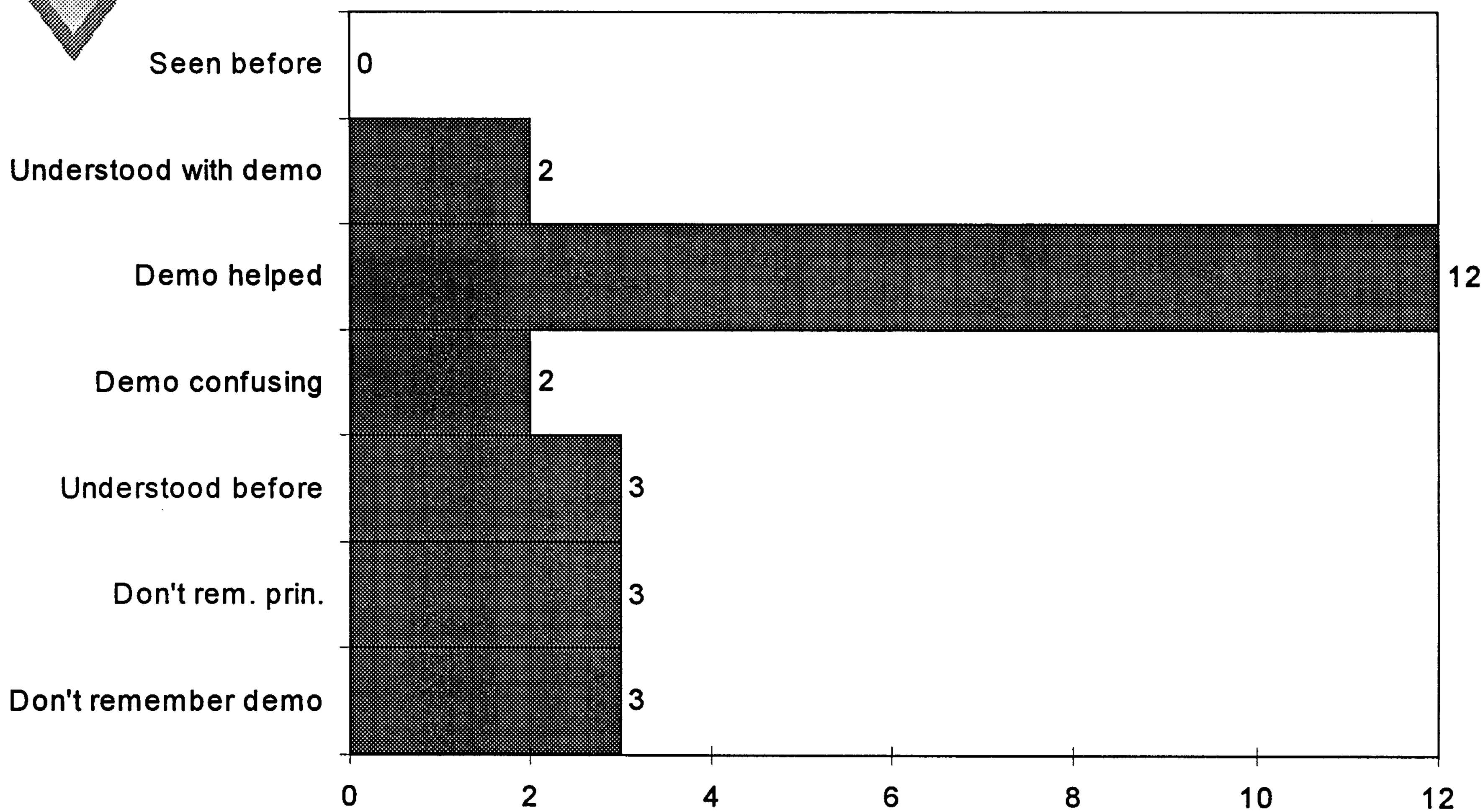
Endothermic reaction



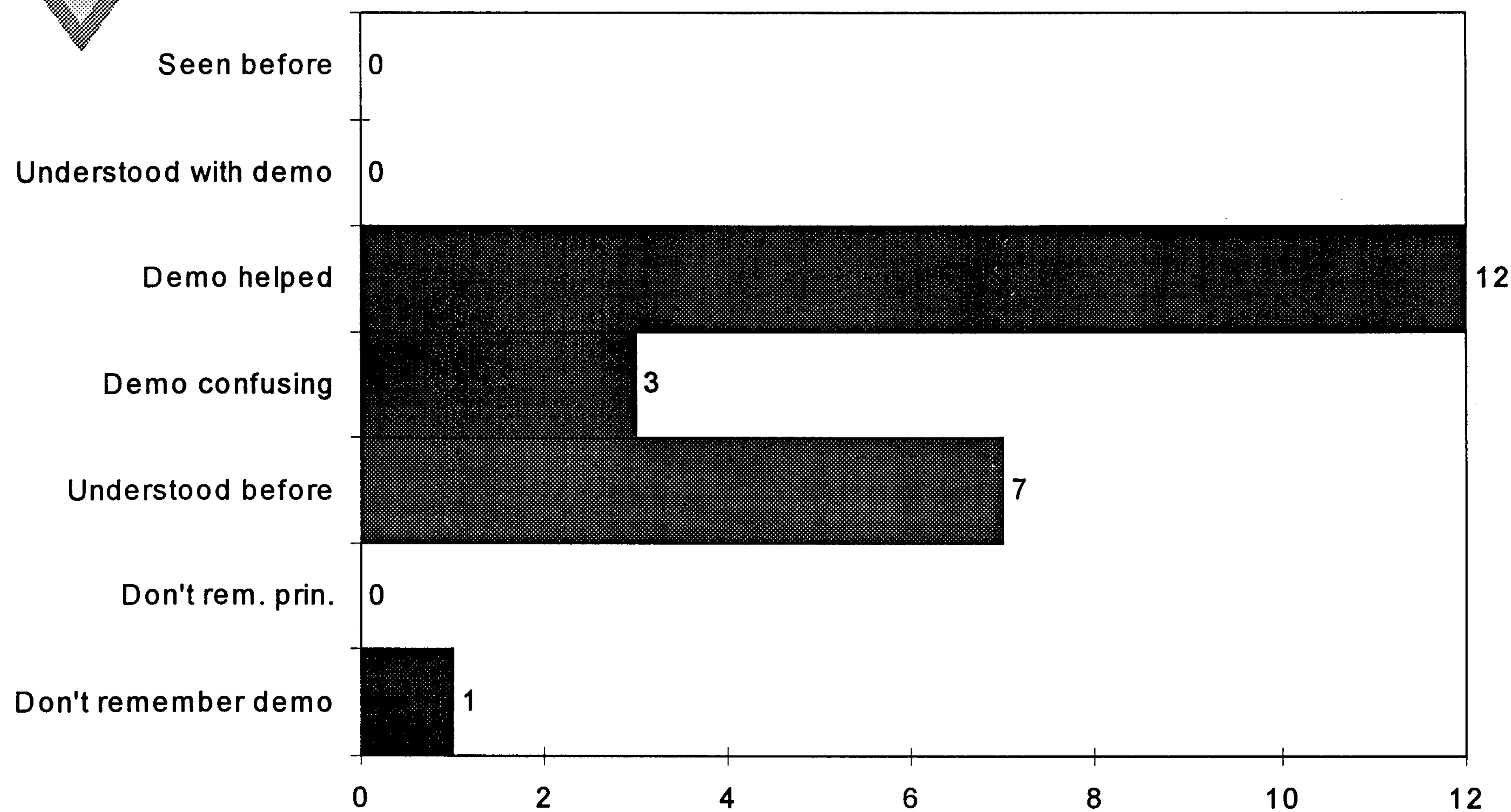
Sugar and sulfuric acid reaction



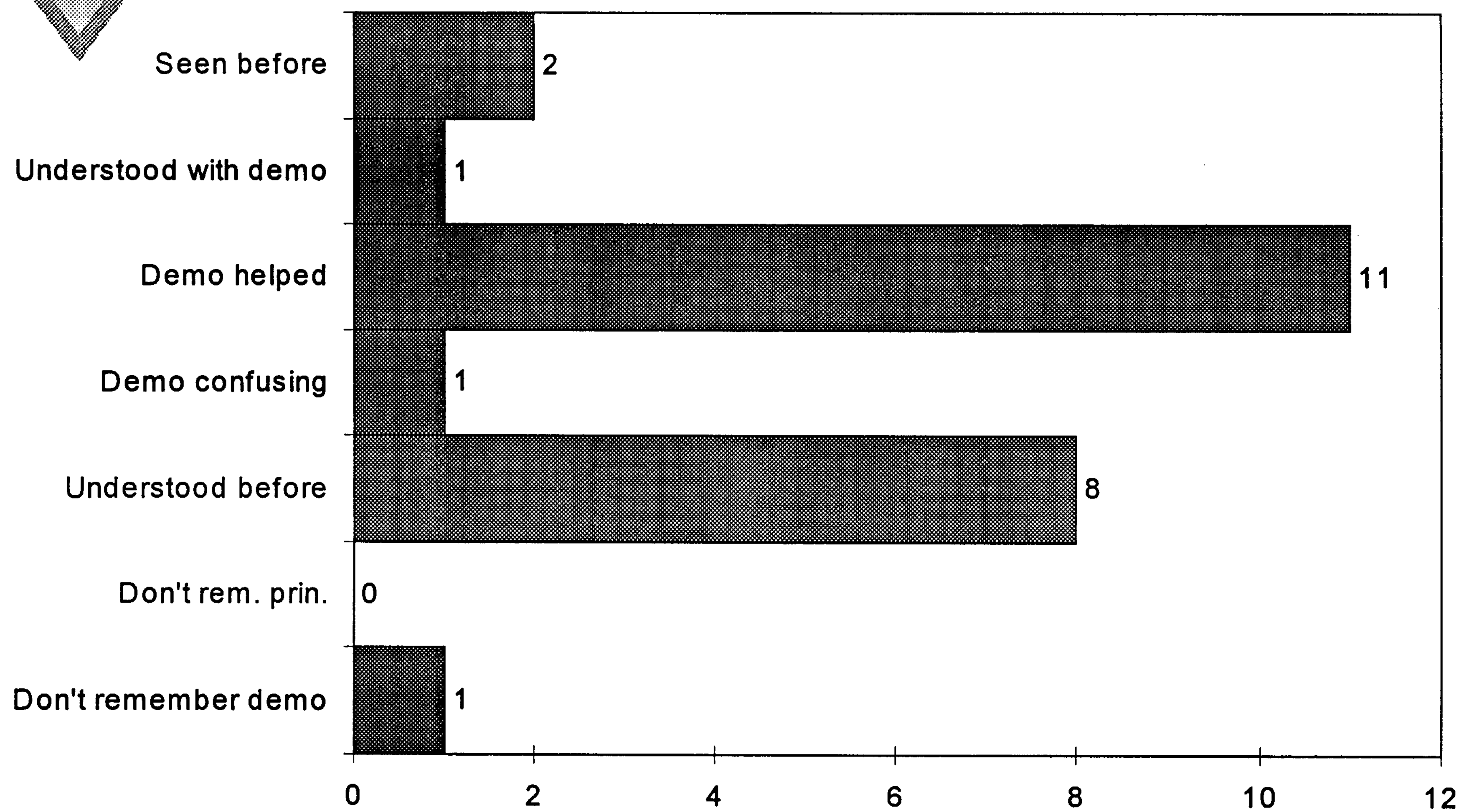
Potassium permanganate and glycerine



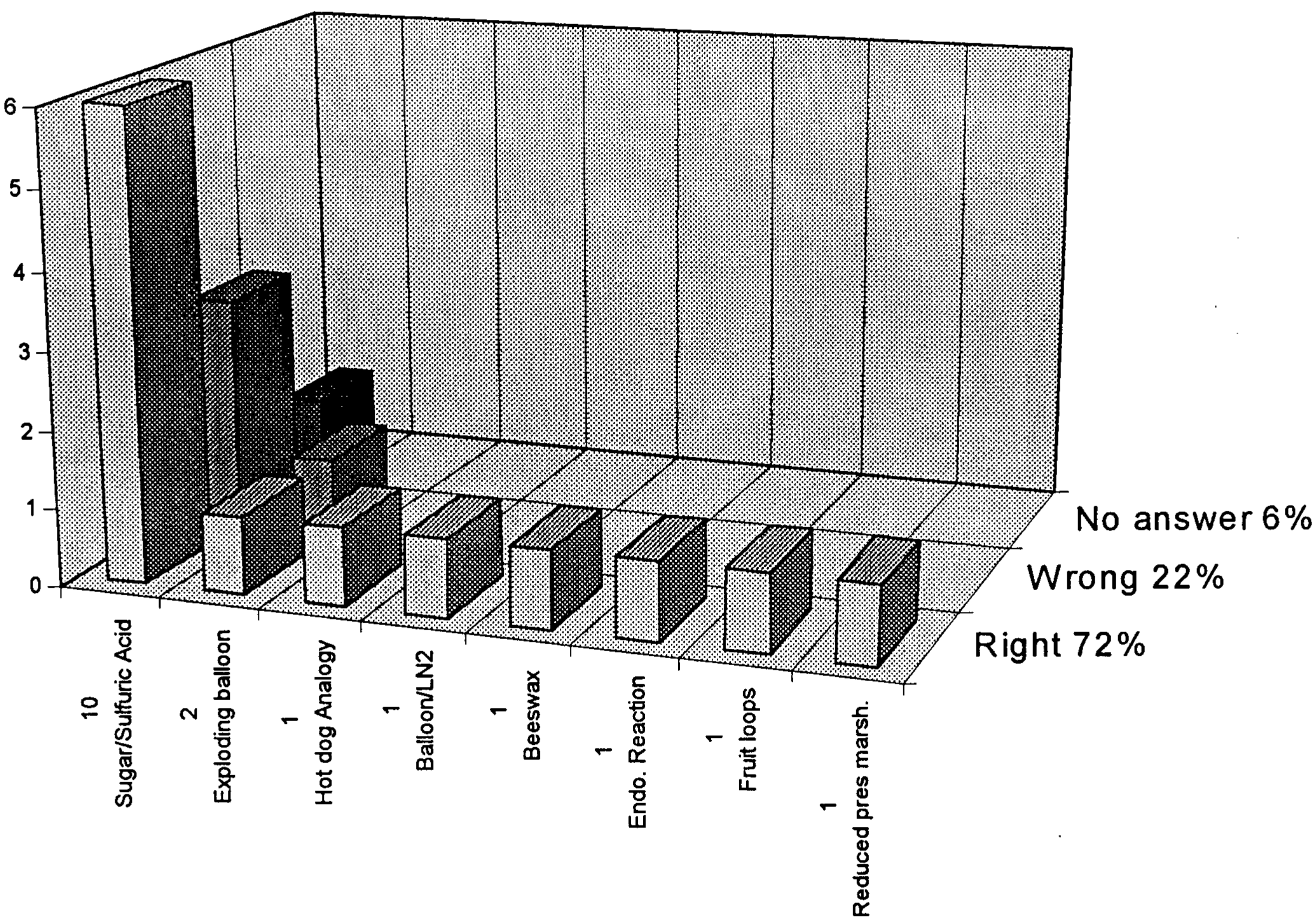
Specific heat capacity



Entropy of 52 card pick-up



Favorite Demonstrations -Principle Illustrated



General Survey Remarks

1. Most demos are good at reinforcing concepts. I think it helps emphasize the concept, rather than increase understanding.

2. The demos are fine. The lectures are effective in teaching the given material, but I think they aren't thorough enough in teaching material we're tested for.

3. I hate the music - seems unnecessary.

4. Please extend this type of class to other science courses - this is great.

5. Possibly use a video tape to display the IRC (in room chat) computer usage necessary for this class. It might help.

6. Animations about what is actually happening would help to reinforce the concepts involved. Only occasionally do the demos add much of value to the learning experience.

7. The video outlines are extremely helpful. The feedback loop is very long (too long). [Example: exams]

8. The demos keep my mind from wandering, you should keep them.

9. I think that this class is great for people who catch on fast or if most of Chem I is a review. For those who need their hand held, this class is not the best choice possible.

10. The videos need to be tied into a specific chemistry textbook, and a more detailed course study guide to help with the distance learning.

11. I have learned so much about chemistry using the videos and on-line tutorials than I did the first time (6-10 years ago) I took chem (a traditional class at CU, Boulder). I think my grasp of this material is much better. What a great way to teach a class!

12. I think the videos are excellent - well presented and well organized. I do not think the videos are challenging enough for material we are expected to master. I would suggest more problems and more difficult problems.

13. The videos are an excellent means of conveying the pertinent information. The graphics are much easier to read than a distant blackboard and there is a tremendous advantage to being able to rewind the tapes.

14. It would be very helpful to all work from the same book and make references to it in the tape. The notes are excellent, please keep.

15. I have never seen demos in a large lecture hall.

16. I have seen very, very few demos - most are considered a little too dangerous to be done in lecture and are done only in a lab setting.

17. The demo for coupling reactions was unclear.

18. The sound quality of one of my tapes was practically inaudible.

19. There was a little too much explaining for the demos.

20. There could have been more depth and discussion for the demonstrations.

21. I showed the demos to my family and friends.

22. I still think understanding endothermic/exothermic are difficult because I confuse the surroundings with the system. Absorbing heat and a freezing surrounding is confusing, but I think the demo is valuable.

Cummulative Results of the Survey for UCD Extended Studies General Chemistry I Students

This study is being conducted as part of my Master's Degree Project. It is designed to evaluate the effectiveness and usefulness of the demonstrations in the videos. This survey should only take about 15 minutes to complete. Your honesty and thoroughness in responses is appreciated. All surveys will remain confidential and anonymous. Your valuable input will help improve the videos for the General Chemistry II Extended Studies Course.

Thank you,
Kristen R. Kull

INSTRUCTIONS: Please mark one or more of the boxes which apply. If you need additional space for an explanatory response, feel free to use the space between the questions or the reverse of this sheet.

1. Overall I thought the demos were:

A /18/ 82% ☐ a valuable addition to the videos with respect to understanding the concepts.

B/4/18% ☐ fun and interesting but not necessary for my understanding.

C/0/0% ☐ interesting but distracted me from concentrating on the lecture material.

D/0/0% ☐ a waste of time and videotape.

2. How interesting or valuable were the demonstrations:

A/11/39% ☐ I found the videotaped demos were **as or more** interesting/valuable than live demonstrations because I could see them better up close than in a lecture hall.

B/12/43% ☐ I found the videotaped demos were **as or more** interesting/valuable than live demonstrations because I could rewind them and watch them again.

C/0/0% ☐ I found the videotaped demos were **less** interesting/exciting/valuable than live in-class demos because ______________________________.

D/5/18% ☐ I have never seen lecture demonstrations in a science class and cannot compare them to the video demos.

3. *I found the presentation and film quality of the videotaped demos:*

A/9/41% ☐ excellent.

B/11/50% ☐ good.

C/2/9% ☐ fair.

D/0/0% ☐ poor.

4. *Overall I found the explanations that accompanied the demos to be:*

A/10/45% ☐ thorough.

B/10/45% ☐ adequate.

C/1/5% ☐ lacking depth.

D/1/5% ☐ inadequate because ________________________________.

5. *I rewound the tape and watched demos again:*

A/7/32.0% ☐ often.

B/12/54.5% ☐ occasionally.

C/3/13.5% ☐ never (skip to # 7).

6. *I rewatched demos because:*

A/7/35% ☐ I thought they were neat.

B/8/40% ☐ I found it helped me to understand the principles the demos illustrated.

C/5/25% ☐ I usually/sometimes did not understand them the first time through.

7. *Which tapes have you watched all or part of?*

____

8. *Of those tapes, which was your favorite demo(s)?*

____

9. *Do you remember what principle it illustrated? (Please state principle)*

____

OPINIONS ON SPECIFIC DEMONSTRATIONS IN THE GASES AND THERMODYNAMICS VIDEO TAPES

10. Opinions about the **expanding balloon in reduced pressure** *on Video # 2.*

2 ❐ I don't remember the demo.

1 ❐ I don't remember what principle the demo illustrated.

9 ❐ I understood the principle before the demo illustrated it.

0 ❐ I understood the principle **better** before the demo illustrated it because the demo confused me.

15 ❐ I found that the demo helped me to understand the principle better.

1 ❐ I did not understand the principle until I saw the demo.

1 ❐ I had seen the demo before this video.

11. Opinions about the **expanding marshmallows in reduced pressure** *demonstration on Video demonstration # 2.*

1 ❐ I don't remember the demo.

3 ❐ I don't remember what principle the demo illustrated.

10 ❐ I understood the principle before the demo illustrated it.

0 ❐ I understood the principle **better** before the demo illustrated it because the demo confused me.

13 ❐ I found that the demo helped me to understand the principle better.

1 ❐ I did not understand I the principle until I saw the demo.

1 ❐ I had seen the demo before this video.

12. Opinions about the **shrinking balloon in liquid nitrogen** *demonstration on Video # 2.*

0 ☐ I don't remember the demo.

0 ☐ I don't remember what principle the demo illustrated.

4 ☐ I understood the principle before the demo illustrated it.

1 ☐ I understood the principle **better** before the demo illustrated it because the demo confused me.

14 ☐ I found that the demo helped me to understand the principle better.

1 ☐ I did not understand the principle until I saw the demo.

3 ☐ I had seen the demo before this video.

13. Opinions about the **marble agitator** *demonstration on Video # 2.*

2 ☐ I don't remember the demo.

0 ☐ I don't remember what principle the demo illustrated.

6 ☐ I understood the principle before the demo illustrated it.

1 ☐ I understood the principle **better** before the demo illustrated it because the demo confused me.

14 ☐ I found that the demo helped me to understand the principle better.

1 ☐ I did not understand the principle until saw the demo.

0 ☐ I had seen the demo before this video.

14. Opinions about the **CO_2 cartridge filling the balloon** *demonstration on Video # 2.*

0 ☐ I don't remember the demo.

3 ☐ I don't remember what principle the demo illustrated.

10 ☐ I understood the principle before the demo it.

1 ☐ I understood the principle **better** before the demo illustrated it because the demo confused me.

9 ☐ I found that the demo helped me to understand the principle better.

0 ☐ I did not understand the principle until I saw the demo.

0 ☐ I had seen the demo before this video.

15. Opinions about the **thermodynamic coupling reaction (pink, green, blue solution)** *demonstration on Video # 3.*

3 ☐ I don't remember the demo.

4 ☐ I don't remember what principle the demo illustrated.

2 ☐ I understood the principle before the demo illustrated it.

4 ☐ I understood the principle **better** before the demo illustrated it because the demo confused me.

6 ☐ I found that the demo helped me to understand the principle better.

6 ☐ I did not understand the principle until I saw the demo.

0 ☐ I had seen the demo before this video.

16. Opinions about the **cork freezing to the beaker** *demonstration on Video # 3.*

4 ☐ I don't remember the demo.

0 ☐ I don't remember what principle the demo illustrated.

3 ☐ I understood the principle before the demo illustrated it.

3 ☐ I understood the principle **better** before the demo illustrated it because the demo confused me.

15 ☐ I found that the demo helped me to understand the principle better.

1 ☐ I did not understand the principle until I saw the demo.

0 ☐ I had seen the demo before this video.

17. Opinions about the **sugar and sulfuric acid** *demonstration on Video # 3.*

3 ☐ I don't remember the demo.

0 ☐ I don't remember what principle the demo illustrated.

4 ☐ I understood the principle before the demo illustrated it.

0 ☐ I understood the principle **better** before the demo illustrated it because the demo confused me.

13 ☐ I found that the demo helped me to understand the principle better.

2 ☐ I did not understand the principle until I saw the demo.

0 ☐ I had seen the demo before this video.

18. Opinions about the **potassium permanganate and glycerin volcanic like** *demonstration on Video # 3.*

3 ☐ I don't remember the demo.

3 ☐ I don't remember what principle the demo illustrated.

3 ☐ I understood the principle before the demo illustrated it.

2 ☐ I understood the principle **better** before the demo illustrated it because the demo confused me.

12 ☐ I found that the demo helped me to understand the principle better.

2 ☐ I did not understand the principle until I saw the demo.

0 ☐ I had seen the demo before this video.

19. Opinions about the **beeswax and heated metal** *demonstration on Video # 3.*

1 ☐ I don't remember the demo.

0 ☐ I don't remember what principle the demo illustrated.

7 ☐ I understood the principle before the demo illustrated it.

3 ☐ I understood the principle **better** before the demo illustrated it because the demo confused me.

12 ☐ I found that the demo helped me to understand the principle better.

0 ☐ I did not understand the principle until I saw the demo.

0 ☐ I had seen the demo before this video.

20. Opinions about the **52-card pick-up** *demonstration on Video # 3.*

1 ☐ I don't remember the demo.

0 ☐ I don't remember what principle the demo illustrated.

8 ☐ I understood the principle before the demo illustrated it.

1 ☐ I understood the principle **better** before the demo illustrated it because the demo confused me.

11 ☐ I found that the demo helped me to understand the principle better.

1 ☐ I did not understand the principle until I saw the demo.

2 ☐ I had seen the demo before this video.

21. In order to understand the chemistry background of the students, please provide the following information:

Previous Chemistry Courses

☐ High School Chemistry

Number of years ago: ☐ 1-5 ☐ 6-10 ☐ 11-15 16+ ☐

☐ College Chemistry

☐ Completed

☐ Started but did not complete, withdrew after ______ weeks.

Number of years ago: ☐ 1-5 ☐ 6-10 ☐ 11-15 ☐ 16+

Other related courses (please list): ____

____

Please include any additional remarks or comments regarding any aspect of the video lectures and demonstrations.

____

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